HEWLETT PACKARD
COMPANY

212A

PULSE GENERATOR

SERIALS PREFIXED: 419

OPERATING AND SERVICING MANUAL

PRINTED 10-59

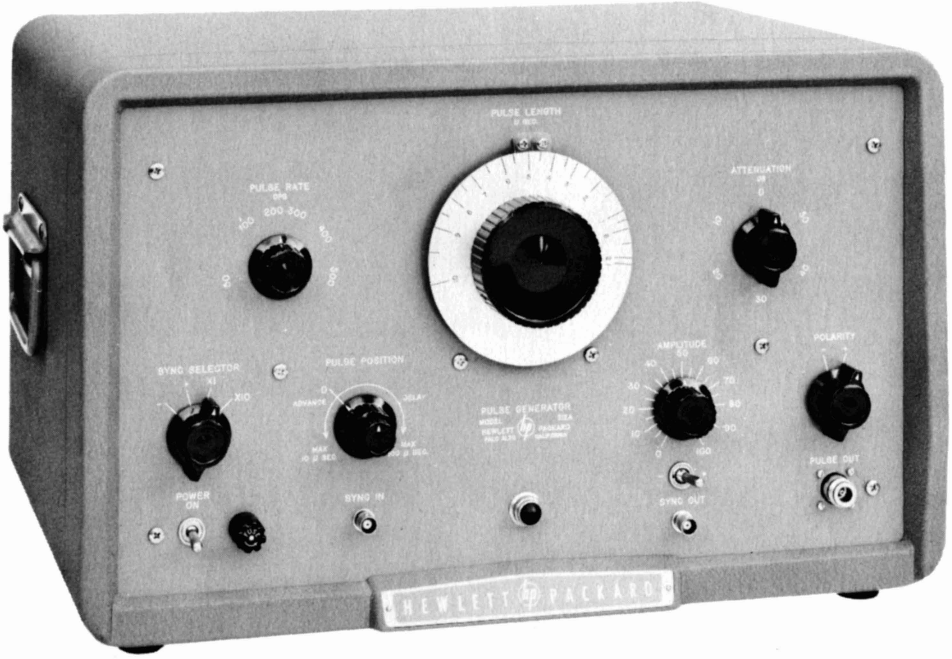
OPERATING AND SERVICING MANUAL

FOR

MODEL 212A

PULSE GENERATOR

Serials Prefixed: 419—


PULSE LENGTH
PULSE RATE
ATTENUATION
SYNC SELECTOR
PULSE POSITION
AMPLITUDE
POLARITY
PULSE GENERATOR
PULSE OUT
POWER ON
SYNC IN
SYNC OUT
HEWLETT PACKARD

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SPECIFICATIONS

PULSE LENGTH:	At least 0.07 to 10 microseconds, continuously variable.
PULSE AMPLITUDE:	At least 50 volts peak into 50 ohm load (50 watts peak).
PULSE POLARITY:	Positive or Negative.
AMPLITUDE CONTROL:	(a) 50 db attenuator, variable in 10 db steps. (b) Continuously variable control with range of at least 10 db.
PULSE SHAPE:	(a) Rise and decay time approximately 0.02 microseconds (10% to 90%). (b) Crest variation less than ±5% of average peak amplitude.
JITTER:	Less than 0.01 microseconds.
INTERNAL IMPEDANCE:	50 ohms or less on either pulse polarity.
REPETITION RATE:	(a) Internal synchronization, 50 to 5,000 pps. (b) External synchronization, ≈2 to 5,000 pps.
SYNC IN:	Positive or negative, 5 volts peak minimum.
SYNC OUT:	(a) 25 volts positive or 15 volts negative into 2,000 ohm load. (b) Duration, approximately 1 microsecond at half voltage points. (c) Rise time, approximately 0.25 microseconds.
PULSE POSITION:	(a) Delay, 0 to 100 microseconds after sync out pulse with repetition rate up to 2500 pps. (b) Delay, 0 to 50 microseconds after sync out pulse with repetition rate up to 5000 pps. (c) Advance, 0 to 10 microseconds after sync out pulse with repetition rate up to 5000 pps.
CONNECTORS:	(a) Main pulse, Type N. (b) Sync in, sync out, Type BNC.
POWER SUPPLY:	115/230 volts ±10%, 50/60 cps, 380 watts maximum.
DIMENSIONS:	Cabinet Mount: 20-3/4" wide, 12-3/4" high, 14-3/16" deep. Rack Mount: 19" wide, 10-1/2" high, 14-3/4" deep.
WEIGHT:	Cabinet Mount: 56 lbs., shipping weight approximately 76 lbs. Rack Mount; 50 lbs., shipping weight approximately 73 lbs.
ACCESSORIES AVAILABLE:	hp AC-16F Cable Assembly, Type N Male to Type N Male Fittings. hp AC-16K Cable Assembly, BNC to BNC. hp #17 End Frames, with handles for bench use, (for 212AR Rack Mount).

TABLE OF CONTENTS

Page No.

Section I GENERAL DESCRIPTION

1-1 General 1-1
1-2 Accessory Cables 1-1

Section II OPERATING INSTRUCTIONS

2-1 Inspection 2-1
2-2 Controls and Terminals 2-1
2-3 Automatic Overload Relay Protection 2-2
2-4 Operation 2-2
2-5 Waveshape of Output Pulse 2-3
2-6 Positive and Negative Pulse Output Levels 2-4
2-7 Operation of Pulse Length and Pulse Rate Controls 2-4
2-8 Operation of Pulse Position Control 2-5

Section III CIRCUIT DESCRIPTION

3-1 General 3-1
3-2 Rep. Rate MV 3-1
3-3 Delay MV and Blocking Oscillator 3-1
3-4 Pulse Position MV and Blocking Oscillator 3-2
3-5 Pulse Forming Thyratron V6 3-2
3-6 Pulse Length MV and Blocking Oscillator 3-2
3-7 Pulse Terminating Thyratron V16 3-3
3-8 Clipper Circuits 3-3
3-9 Output Amplifier 3-3
3-10 Power Supply 3-3

Section IV MAINTENANCE

4-1 Output Pulse Analysis. 4-1
4-2 Adjustments 4-3
4-3 Servicing Negative High Voltage Supply (V4, V12, V14, etc.) 4-5
4-4 Thyratron Replacement 4-5
4-5 Replacement of Load Resistor R21 and R22 4-6
4-6 Trouble Shooting Chart 4-7

Section V TABLE OF REPLACEABLE PARTS 5-1

SECTION I

GENERAL DESCRIPTION

1-1 GENERAL

The Model 212A Pulse Generator is a fundamental measuring instrument for determining the action of circuits under conditions of rapid change.

The pulse produced by this instrument has a short time of rise and decay with a flat top and minimum of overshoot. Either positive or negative pulses are available and the pulse shape is independent of the repetition rate, connected load, sync condition, supply voltages, and output attenuator setting. The pulse length is continuously variable from .07 to 10 microseconds.

This instrument is applicable to the testing of radar systems, nuclear counting circuits, television systems, response of video amplifiers, filters and band pass circuits and pulse modulation of UHF signal generators.

1-2 ACCESSORY CABLES

AC-16K: RG-58/U 50 ohm coaxial cable terminated each end with UG-88/U Type BNC male connector. Overall length 48".

AC-16B: RG-58/U 50 ohm coaxial cable terminated on one end with UG-88/U Type BNC male connector and dual banana plug (3/4" center) on the other end. Overall length 45".

AC-16D: RG-58/U coaxial cable terminated one end only with UG-88/U Type BNC male connector. Overall length 44".

AC-16C: RG-9A/U 50 ohm coaxial cable terminated one end with UG-21B/U Type N male connector and UG-23B/U Type N female connector at other end. Overall length 72".

AC-16F: RG-9A/U 50 ohm coaxial cable terminated on each end with UG-21B/U Type N male connectors. Overall length 72".

SECTION II

OPERATING INSTRUCTIONS

2-1 INSPECTION

Refer to the Warranty sheet in this manual.

2-2 CONTROLS AND TERMINALS

PULSE OUT
This terminal is a Type N jack located at the lower right corner of the front panel. It is the output connection for the main pulse.

SYNC OUT
This terminal is a BNC terminal on the lower right side of the panel. This terminal provides a voltage to synchronize an oscilloscope or other device for use with the Pulse Generator.

+, —
This toggle switch, on the panel above the SYNC OUT terminal, controls the polarity of the synchronizing voltage fed to the SYNC OUT terminal.

SYNC IN
The SYNC IN terminal is a BNC connector on the lower left side of the panel. A voltage can be fed into this terminal to trigger the pulse generating circuit.

SYNC SELECTOR
The SYNC SELECTOR knob selects two ranges of internally generated pulse rates, and also selects necessary circuitry for external synchronization from either positive or negative externally generated sync pulses.

PULSE POSITION
The PULSE POSITION control adjusts the timing between the MAIN PULSE OUTPUT and the SYNC OUTPUT pulse. Its main use is to position the main pulse on an oscilloscope screen when the oscilloscope has been synchronized with the SYNC OUT pulse.

PULSE RATE
The PULSE RATE control, located on the upper left hand side of the panel, adjusts the repetition rates of the pulse from 50 to 5000 cycles per second in conjunction with the X1 and X10 position of the SYNC SELECTOR switch.

PULSE WIDTH
The PULSE WIDTH control is the large dial at the center of the panel and controls the width of the MAIN OUTPUT pulse.

AMPLITUDE
The AMPLITUDE control gives a continuous variation of the MAIN OUTPUT pulse.

ATTENUATION
The ATTENUATION control, located on the right hand side of the panel, provides attenuation of the Main pulse in 10 db steps so that low levels of pulse output can be obtained.

POLARITY
The POLARITY control at the lower right hand side of the panel switches the polarity of the MAIN OUTPUT pulse from positive to negative.

FUSE
The fuseholder, on the panel next to the POWER ON switch, contains a 4 ampere cartridge fuse. A 2 ampere fuse should be used when the power transformer is connected for 230V operation. The fuse may be replaced by unscrewing the fuseholder cap and inserting a new fuse.

2-3 AUTOMATIC OVERLOAD RELAY PROTECTION

An overload relay is incorporated in the instrument to protect the ⓗⓟ 45B thyratron if, for any reason, continuous plate current conduction occurs. Operation of the relay is indicated by a buzzing sound. If this occurs when the instrument is first turned on, it may indicate that there is insufficient warm-up and turning the SYNC SELECTOR to the + or – position without any external triggering for two or three minutes should then place the instrument in normal operating condition.

2-4 OPERATION

The Model 212A Pulse Generator is operated as follows:

1. Plug the power cable into a nominal 115V, 50 to 60 cycles power line and turn on the toggle switch. (The pilot lamp should light when the switch is on.)

2. Allow several minutes for the instrument to warm up with the SYNC SELECTOR in the + or – position and with no sync in. Although the unit can be used after 2 or 3 minutes of warm up, it is desirable to allow about ten minutes warm up time if possible.

3. Connect the equipment to be driven to the PULSE OUT terminal. This connection should be made, if possible, through a nominal

50 ohm cable.

NOTE

The output circuit of the Model 212A is terminated with approximately 50 ohms so termination of the output cable with 50 ohms is not absolutely necessary for many measurements. If the overall system is sensitive to frequencies on the order of 20 to 30 megacycles, the output cable should be terminated in a non-inductive 50 ohm load to prevent reflections from the load which may cause ringing. This is especially true when the ATTENUATION and OUTPUT controls are set for full output. Under these conditions the Model 212A OUTPUT source impedence is less than 50 ohms thus resulting in an imperfect output cable termination at the source end.

The SYNC OUT terminal may be connected to the synchronizing terminals on an oscilloscope and the polarity of the SYNC OUT signal may be switched to select the best performance. The SYNC SELECTOR should be set to either the X1 or the X10 position, and the PULSE RATE dial set to the desired repetition rate. The PULSE WIDTH dial may then be set to select the pulse width desired and the PULSE POSITION control is then adjusted until the pulse appears at the desired position on the oscilloscope screen. The amplitude of the pulse can be adjusted by means of the AMPLITUDE CONTROL and the OUTPUT ATTENUATOR to give the desired output level.

CAUTION

Do not set the PULSE POSITION delay to greater than 50 microseconds when a repetition rate of 5000 cps is used. Maximum delay of 100 microseconds may be used for repetition rates up to 2500 cps. Above 2500 cps the maximum delay must be decreased as the repetition rate is increased so as not to overload the tubes in the pulse position circuit.

2-5 WAVESHAPE OF OUTPUT PULSE

The output pulse from the Model 212A has extremely good waveshape and, in general, the waveshape is quite independent of the load and the operating conditions of the Pulse Generator. However, when the generator is operated at zero attenuation, with a length of cable between the generator and an unterminated load, reflections may occur due to the internal impedance of the generator being less than 50 ohms. This condition may be corrected by properly terminating the cable. As the attenuation is increased, the internal impedance approaches 50 ohms.

The waveshape is **best** with the AMPLITUDE control set to provide about 50 volts of output. As the amplitude is reduced with the AMPLITUDE control, the waveshape deteriorates slightly and, if the best waveshape is desired, it is preferable to reduce the output level with the attenuator and operate the AMPLITUDE control as close to the 50 volts position as possible.

The AMPLITUDE control is not calibrated, but, with no attenuation in the circuit, there will be at least 50 volts peak available from the output terminals into a 50 ohm load. On most units, the maximum position of the AMPLITUDE control will give appreciably more than 50 volts output. Unless this additional output is absolutely necessary, it is desirable to operate the unit with the AMPLITUDE control slightly below the maximum position. In some cases the pulse output waveshape will show a little deterioration with the AMPLITUDE control at full maximum.

2-6 POSITIVE AND NEGATIVE PULSE OUTPUT LEVELS

The positive and negative pulse outputs are adjusted to be approximately equal and either can be selected by means of the switch on the front panel. These outputs, however, cannot be expected to have exactly the same value and it is normal that there will be a little difference in amplitude between the positive and negative output position.

2-7 OPERATION OF PULSE LENGTH AND PULSE RATE CONTROLS

The pulse length is adjustable from less than .07 of a microsecond to 10 microseconds. This continuously adjustable feature in the Model 212A is convenient for a great many applications and is one of the useful features of this instrument. The generation of these very short, continuously adjustable pulses involves a differential operation whereby the difference between two larger time periods is used to control the actual time of the output pulse duration.

With this excellent flexibility in the control of the pulse output, there is a little sacrifice in absolute accuracy. In general the pulse length control can be expected to be correct within ±10 percent except for very short pulse lengths where considerably more variation in the length may be obtained from time to time. Where accurate pulse lengths are necessary, it is desirable to use some sort of an auxiliary calibrating means to set the pulse length to the correct value. One of the main causes of variation in the pulse length is the variation in the characteristics of the hydrogen thyratron tubes used in the equipment. As tubes are changed in the equipment, some change in pulse length will be obtained, and also there may be some change in the pulse length calibration as the tubes age over a period of time. Controls are provided on the chassis just behind the main pulse dial so that the pulse length calibration can be reset from time to time if necessary. See Section IV, Maintenance, regarding the adjustment of these controls.

The length of the main pulse is essentially independent of the other controls except that the pulse length will tend to change slightly as the repetition rate is changed especially above repetition rates of 1 kc.

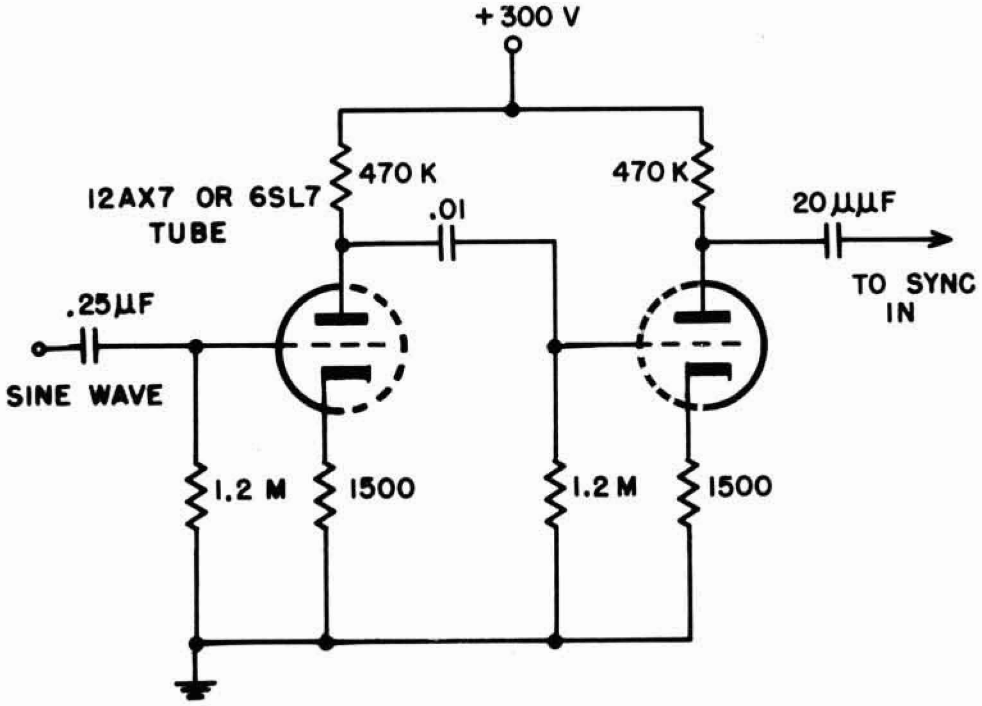
The internal repetition rate generator is a multivibrator adjustable over the range from 50 to 5000 cycles/sec. Calibration of this control should, in general, hold within ±25%, but when accurate repetition rates are desired, it is preferable to use an external oscillator to drive the pulse generator. The Model 212A can be synchronized from external pulses having at least a 5 volt amplitude and a rise time in the order of a microsecond or two. If it is desired to synchronize from a sine wave source, it is necessary to use a wave shaper of some sort to increase the rise time of the synchronizing voltage. The unit synchronizes very well from an ⓗⓟ Model 211A Square Wave Generator. Another typical waveshaper which may be used for a sine wave input is shown in Figure 2-1.

It is important that the Model 212A not be driven at a pulse rate in excess of 5000 cycles/sec. Performance at this end of the range is limited mainly by the duty cycle of the thyratrons. There is practically no limit to the repetition rate at the low frequency end provided the synchronizing pulses have a time-of-rise in the order of one or two microseconds.

Since the unit is limited by duty cycle at high repetition rates and long pulse widths, there is a tendency for the amplitude to be affected by repetition rates especially when the repetition rate is above 1000 cycles/sec and when the pulse width is at the maximum value. However, compensating circuits have been incorporated in the unit to minimize these amplitude variations and for most purposes they are not serious.

2-8 OPERATION OF PULSE POSITION CONTROL

The PULSE POSITION control is designed to adjust the main pulse timing around the SYNC OUT timing. This control will set the main pulse ahead of the sync out by approximately 10 microseconds or after the sync out by approximately 100 microseconds. This control is not calibrated as its main use is to position the main pulse on an oscilloscope screen. This pulse position will tend to be affected to some extent by the pulse rate. This condition is normal and should cause no serious difficulty under normal operating conditions. See important precaution given at the end of paragraph 2-4.


+300 V
470 K
470 K
12AX7 OR 6SL7
TUBE
.01
20 µµF
.25 µF
SINE WAVE
TO SYNC
IN
1.2 M
1500
1.2 M
1500

Schematic Wiring Diagram of a Typical Wave Shaper

Fig. 2-1

SECTION III

CIRCUIT DESCRIPTION

3-1 GENERAL

The Model 212A Pulse Generator consists of three basic parts, the triggering circuits which are located in the front deck, the main pulse generating circuits, and the power supply which are located in the rear deck. The block diagram of the triggering and main pulse generating circuits are shown in Figure 3-1. All of the triggering circuits are located to the left of the thyratrons V6 and V16. This block diagram and the schematic wiring diagram will both be referred to in the following circuit description.

3-2 REP. RATE MV

This section of the circuit consists of an amplifier, phase inverter, and a multivibrator. The amplifier tube V103A and the phase inverter tube V103B in conjunction with switch S102A are used to deliver a negative pulse to the input of the multivibrator.

The repetition rate multivibrator consists of tube V104AB and may be operated either free running or triggered by an external pulse. In the free running condition it generates pulses at the repetition rate of 50-5000 pulses per second or in the externally synchronized condition it may be externally triggered up to 5000 pulses per second.

When the multivibrator is externally synchronized, it is biased so that it generates a pulse only when triggered by the external pulse.

The pulses generated by this multivibrator are supplied to the delay multivibrator and the pulse position multivibrator.

3-3 DELAY MV AND BLOCKING OSCILLATOR

Tube V101AB is employed as a "one shot" multivibrator. The pulse from the repetition rate multivibrator triggers the delay multivibrator to produce a positive 15 microsecond pulse which is inverted by V102A. The trailing edge of the 15 microsecond pulse then triggers the blocking oscillator.

The blocking oscillator tube V102B forms the sync out pulse which is supplied to the sync out terminals of the instrument through a polarity reversing switch.

3-4 PULSE POSITION MV AND BLOCKING OSCILLATOR

The pulse position multivibrator tube V105AB is also a one shot multivibrator which is triggered by the pulse from the repetition rate multivibrator. A positive pulse 2 to 112 microseconds in length is produced by this multivibrator. The duration of this pulse is controlled by the variable resistor R132.

The blocking oscillator tube V106B forms the pulse which is supplied to the pulse length multivibrator and the delay line. Following the blocking oscillator is a cathode follower tube V107B which couples the blocking oscillator to the delay line. In series with the grid of this tube is a crystal rectifier CR104 and a resistor R152 which prevent reflections from the delay line being fed to the blocking oscillator circuit due to the cathode to grid capacity of V107B.

3-5 PULSE FORMING THYRATRON V6

Tube V2, which is normally connected as a diode, and the charging choke L2 are used to charge the pulse forming line so that plate voltage is applied to the pulse forming thyratron V6. If for any reason the thyratron draws excessive current, then the relay REL-1 applies a large negative voltage to the grid of the tube V2 thereby stopping the flow of current to V6.

When the pulse forming line is charged, a pulse from the blocking oscillator and delay line will trigger the thyratron tube. Once the thyratron tube is fired, it will continue to carry current, irrespective of the grid voltage, until the conduction is quenched by means of the pulse forming line. The pulse forming line causes the plate voltage to fall to zero after 10 microseconds due to a reverse polarity transient which travels down to the open end of the line and is reflected back to the starting point. This action limits the tube conduction and forms a 10 microsecond pulse across the cathode resistor R13.

The damping diode tube V3 is used to damp out any negative overshoots.

3-6 PULSE LENGTH MV AND BLOCKING OSCILLATOR

The positive pulse from the blocking oscillator V106B is inverted by tube V107A. The negative pulse from V107A triggers the pulse length multivibrator consisting of V108A and V108B. The pulse length is varied by the PULSE LENGTH control (R142).

The trailing edge of the negative pulse from the multivibrator triggers the blocking oscillator V109A. The output of the blocking oscillator is passed on to the thyratron V16 through the cathode follower tube V109B.

3-7 PULSE TERMINATING THYRATRON V16

The pulse from tube V109B triggers the pulse terminating thyratron V16. When fired, this thyratron in conjunction with the discharge diode V8 presents a very low impedance to the pulse from the pulse forming thyratron V6 and causes a rapid fall of the pulse to form the trailing edge.

Additional direct current voltage is supplied to V16 by means of R28 and allows the pulse terminating thyratron to fire when the pulse length is set to a very low value. Tube V8 in conjunction with R10 and C24 allows the thyratron V16 to be extinguished at the end of the pulse cycle.

3-8 CLIPPER CIRCUITS

The pulse from the thyratron is sent through a series of three diode clippers and then to the output amplifier tube V11. Tube V7 is the first diode clipper. Tube V9 is the second and third diode clipper.

3-9 OUTPUT AMPLIFIER

The output amplifier tube V11 feeds the polarity switch where either a plus or minus pulse may be selected and applied to the attenuator. The attenuator is then used to reduce the pulse 10 db steps.

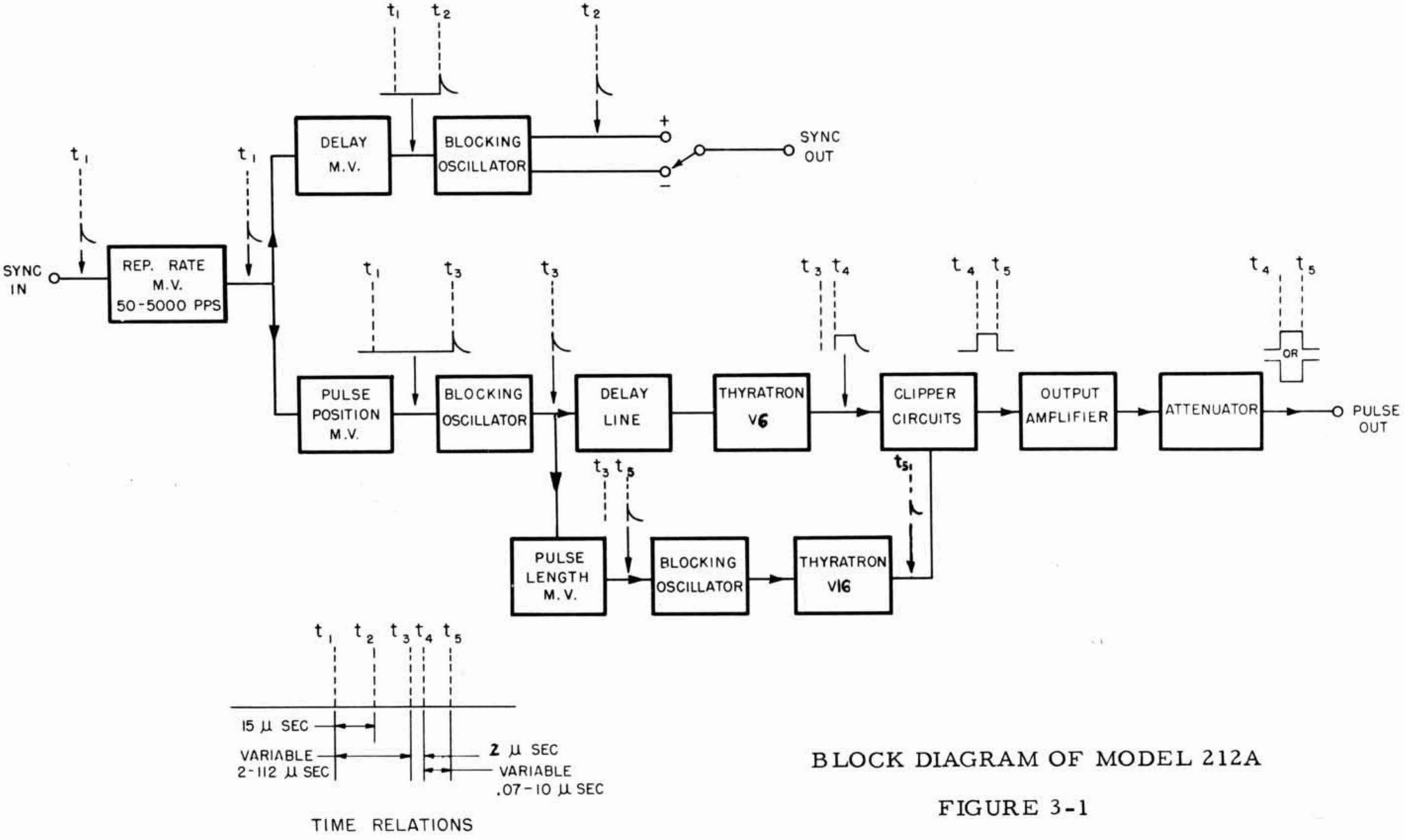
Intermediate values of amplitude may be selected by means of the AMPLITUDE control which has a continuous range of more than 10 db.

This control consists of two ganged variable resistors which vary the grid bias and plate voltage on the output amplifier tube V11 and the cathode voltage on the two clipper tubes V7 and V9.

In order to provide a more constant pulse output amplitude with changes in repetition rate and pulse width, a compensation circuit is incorporated in the unit. When the rate or pulse width is increased, a positive voltage is applied to the cathode of V15 through R51 which causes the voltage to the plate of the output tube and bias of the clippers to increase thereby compensating for the otherwise decrease in output amplitude when the rate or pulse width is increased.

3-10 POWER SUPPLY

The power supply circuits are conventional, and the direct current supply voltages are regulated either by glow discharge type regulator tubes (V4, V12, V14) or by electronic regulators (V10B, V17A, V17B). Tubes V10B and V17B are used to regulate the +300V supply. Tubes V15 and V17 regulate the voltage supplied to the clipper and output amplifier circuits.


SYNC IN
REP. RATE M.V. 50-5000 PPS
DELAY M.V.
BLOCKING OSCILLATOR
+
−
SYNC OUT
PULSE POSITION M.V.
BLOCKING OSCILLATOR
DELAY LINE
THYRATRON V6
CLIPPER CIRCUITS
OUTPUT AMPLIFIER
ATTENUATOR
PULSE OUT
OR
PULSE LENGTH M.V.
BLOCKING OSCILLATOR
THYRATRON V16
t1
t2
t3
t4
t5
15 µ SEC
VARIABLE 2-112 µ SEC
2 µ SEC
VARIABLE .07-10 µ SEC
TIME RELATIONS

BLOCK DIAGRAM OF MODEL 212A

FIGURE 3-1

SECTION IV

MAINTENANCE

4-1 OUTPUT PULSE ANALYSIS

The output pulse of the Model 212A Pulse Generator will be divided into three parts: the leading edge, the top or body, and the trailing edge. Each part is affected by different circuits. If a defect appears on a part of the output pulse, it will generally indicate the circuit at fault. Each part of the pulse is described separately and the list of symptoms in the trouble shooting chart follows the same general order.

Leading Edge -- V6, the 'start' thyratron, 'turns on' the output pulse. V107B triggers V6 and V6 forms the leading edge of the output pulse. Only the circuits of V6 and V107B are responsible for the condition of the leading edge of the output pulse. A defect that appears on the leading edge only, such as jitter and slowness, is the direct result of a defective tube, crystal diode, or other component in the circuits of V6 and V107B. See items 2, 3, and 4 of trouble shooting chart.

Overshoot -- Overshoot occurs to a greater degree on the leading edge of the pulse than on the trailing edge. Overshoot greater than specified is usually caused by leads used for external connections to the pulse generator.

Very minor overshoot coming from the pulse generator is caused by component construction, wiring and lead length within the instrument. V10A compensates for this overshoot on the leading edges of both negative and positive output pulses. This tube amplifies a portion of the rise time from thyratron V6 and couples it to the plate circuit of V11 for negative pulses and to the cathode circuit for positive pulses. The degree of compensation is controlled by adjustable ceramic capacitors C11 and C22. The setting of each capacitor affects that of the other. The final adjustment is accomplished by alternately adjusting the two capacitors while observing both positive and negative pulses. Adjust for optimum pulse shape. C11 is generally set near minimum capacity. C22 is used for a greater portion of the adjustment. See item 5 of the trouble shooting chart.

Top of Pulse -- When V6 is triggered, it generates a pulse limited in length by the time plate voltage supplied to this tube. To protect V6, the supply is constructed to momentarily stop power delivery approximately 11 microseconds from the time V6 fires. V6 is then extinguished and will not fire until re-triggered.

The pulse generated by V6 is very coarse and contains peaks in excess of 500 volts. Clippers V7 and V9 clip the amplitude to between 250 and 350 volts depending upon setting of the AMPLITUDE control. A flat-top pulse is now formed for application to the output amplifier V11. V11 is biased well beyond cutoff. As a result of the high bias voltage only the top portion of the clipped pulse generated by V6 is passed through V11. The very high bias on V11 removes unwanted signals of low amplitude that would otherwise appear on the baseline following the output pulse. See items 24 and 25 in trouble shooting chart.

The body of the final output pulse depends upon sufficient power from the high voltage supply to maintain high initial pulse amplitude. A droop in in the pulse body generally indicates a defective component in the high-voltage supply. See item 6 of trouble shooting chart.

If the pulse contains peaks or humps above the normal level of the top, it would indicate ineffective clipping, see items 7 and 8 of trouble shooting chart. When the top has a gradual rise or drop, the correction may be a matter of adjustment and is covered in item 11 of the trouble shooting chart.

Trailing Edge -- V16 the 'stop' thyratron, 'turns off' the output pulse. When V16 is triggered, it forms the trailing edge of the pulse. The trigger pulse for the stop tube is developed by the circuits of amplifier 107a, multivibrator V108 and blocking oscillator V109a. The condition of the trailing edge is the result of all these circuits, plus V8 which is in series with 'stop' thyratron V16. The effects of these circuits can appear only on the trailing edge of the output pulse. See items 13 and 14 of trouble shooting chart.

"Both"Edges of Output Pulse -- If a trouble such as 'jitter' appears on both leading and trailing edges of the output pulse, the defect is generally in a circuit which affects both start and stop thyratrons simultaneously. All circuits preceding V107b, (V101 through V106b) affect both leading and trailing edges and do not affect one edge without affecting the other.

Pulse Length -- A change in pulse length caused by an increase or decrease in rate is generally due to one of the thyratrons. In some thyratrons there is a very small time lapse between the time the tube is triggered and the time the gas is fully ionized. The degree of time lapse depends on the duty cycle. This characterisitic causes the pulse length to vary with rate. Generally, the time lapse increases with an increase in duty cycle. If the start tube has this characteristic, an increase in pulse rate will cause the output pulse to shorten. If the stop tube has this characteristic, the output pulse will lengthen with an increase in rate. See item 17 of trouble shooting chart.

High pulse rates tax both thyratrons to a greater degree than low rates. The symptoms of a failing thyratron therefore become more noticeable at higher pulse rates.

The greatest duty cycle for the stop thyratron, V16, occurs at maximum pulse rate and minimum pulse length. At that time it is conducting for the longest period of time. Under these conditions the stop thyratron will be most subject to jitter and slowness.

Microphonics -- Microphonics usually appear as a small jump in pulse position. Multivibrator tubes V101 and V105 are particularly subject to microphonics. When changing V101 and V105, it may be necessary to try several new tubes to obtain one which is not microphonic and which gives the required advance and delay. A small jump in the trailing edge only would indicate that V108 is microphonic.

A quick operational check for 12AU7 tubes can be made by exchanging with a 12AU7 not in a critical circuit, any position other than V101 or V105.

Interference Through Power Line -- Interference through the power line can occur when instruments on the line are not filtered or if transformers connecting to the line do not have shields between the primary and secondary windings. The interference may appear in various forms. A visual indication may be seen when viewing very low amplitude pulses on a very high sensitivity oscilloscope. The interference will cause ringing at the leading and trailing edges of the pulse.

In some models of the 212A Pulse Generator the filament transformer was constructed without an internal shield. Some of these models contained a line filter which is not shown in the schematic diagrams. If an instrument is known to cause interference through the power line, the line filter circuit shown at the rear of the manual should be added.

4-2 ADJUSTMENTS

Pulse Length Calibration -- The PULSE LENGTH dial is hand calibrated to the potentiometer in the pulse length multivibrator circuit. Composition potentiometers vary greatly in taper and can change taper after use. The calibration of the PULSE LENGTH dial will be only approximately correct after the potentiometer has been replaced or has aged. An external time standard is necessary where high accuracy is required.

Following replacement of a component within the circuits V108 the calibration of the PULSE LENGTH dial should be checked. If necessary, the dial calibration may be adjusted for greater accuracy as follows:

1. With pulse generator connected to a calibrated oscilloscope, set the PULSE LENGTH dial to 10.

2. If necessary, adjust C128 to obtain a pulse length of exactly 10 microseconds.

3. Set PULSE LENGTH dial to .1.

4. If necessary, adjust R143 to obtain a pulse length of .1 microsecond.

5. Check accuracy of other points on dial. The dial may be slipped on the shaft and the above adjustments refined for greatest overall accuracy.

6. If unable to bring close enough, particularly following replacement of R142, recalibration of a new dial will be required.

Pulse Rate Calibration -- The PULSE RATE dial is used only for approximate setting of the repetition frequency and its calibration is not meant to have high accuracy. Adjust as follows:

1. With the equipment operating set SYNC SELECTOR switch to the X10 position and the PULSE RATE dial to maximum clockwise position.

2. Adjust R124 to obtain a pulse rate of 5000 to 5200 pps.

3. With PULSE RATE control unchanged set SYNC SELECTOR switch to the X1 position.

4. Adjust R121 to obtain a pulse rate of 520 pps. The settings of R124 and R121 are interdependent. Steps 2 and 4 must be repeated until the desired maximum pulse rates are obtained on both the X1 and X10 ranges.

5. Set PULSE RATE dial and SYNC SELECTOR switch to obtain a repetition rate of 1000 pps. Loosen set screw in dial and set to read "100". Tighten set screw lightly.

6. Check other points on the dial for accuracy of calibration. Readjust the above settings for best compromise on overall accuracy.

Pulse Position Calibration -- No adjustments are provided for setting the PULSE POSITION control. The position of "0" delay or advance is obtained by slipping the dial on the shaft to the correct position.

The maximum delay obtainable depends on V105.

The maximum advance obtainable depends on V101.

NOTE

At maximum rate do not use delays in excess of 50 microseconds, or, at max. delay do not use rates in excess of 2500 pps.

Power Supply Adjustment -- The D. C. output voltage of the regulator is adjusted by varying the grid bias of the amplifier tube with a potentiometer. Following service to the power supplies, three checks must be made as follows:

1. Check voltage between the cathode (pin 6) of V17 and ground. If necessary, adjust R33 to obtain 300 volts.
2. Check voltage between the center terminal of R110 and ground. If necessary, with instrument not pulsing, adjust R110 to obtain -28 volts at the center terminal.
3. Check maximum output pulse amplitude. If necessary, adjust R35 to obtain 60 volt pulse amplitude.

Relay Adjustment -- (Normally not required for life of relay)

1. Open circuit between relay and R28.
2. Insert milliammeter between relay and pin 5 of V17.
3. Set pulse rate dial at max. and sync selector to X10.
4. Control current through relay by varying R124. Set relay to actuate at 50 ma by adjusting tension on armature springs.
5. Reconnect R28 to relay and reset pulse calibration.

4-3 SERVICING NEGATIVE HIGH VOLTAGE SUPPLY (V4, V12, V14, Etc.)

Following replacement of parts within the negative high voltage supply the current through the voltage regulator tube V4 should be measured at line voltages of 105 and 125 volts. If necessary, the value of R1 may be padded to obtain not less than 10 milli-amperes with a line voltage of 105 volts and not more than 30 milli-amperes with a line voltage of 125 volts.

4-4 THYRATRON REPLACEMENT

V6 and V16 are critical tube positions. To quickly check a thyratron suspected of being faulty interchange V6 and V16 to see if the observed symptoms change as the tubes are exchanged. For example, if jitter is observed on the trailing edge of the pulse, but not on the leading edge, exchange V6 and V16. If jitter now appears on the leading edge and not on the trailing edge as it did before, the trouble is clearly a result of the thyratron now in the V6 position. However, if the jitter remains on the trailing edge in spite of the tube change, the trouble is most likely in the circuits associated

When replacing V6 and V16, the replacement tube should be a type HP45B. The HP45 is specially manufactured for use in the Model 212A. If a standard 3C45 thyratron is used for replacement, aging will be necessary (see following paragraphs). It may be expected that a high percentage of standard 3C45 replacements will not successfully operate in this instrument. If a type HP45B is used, aging and tube selection should not be required.

When a 3C45 is used to replace a thyratron in the Model 212A Pulse Generator, proceed as follows:

1. Remove screen cover from the back of the instrument.
2. Release tube clamp and remove suspected thyratron. Place asbestos cover over replacement tube, place tube in socket and tighten clamp. On V6 also change plate shield to new tube.
3. Prepare to operate instrument. Set the SYNC SELECTOR switch to the – or + position so the instrument will not pulse when turned on. Set RATE control to minimum and the PULSE LENGTH contro to 10 microseconds.
4. Turn instrument on and allow to heat for approximately ten minutes.
5. Set the SYNC SELECTOR switch to the X1 position. The relay may chatter for up to one minute and stop.
6. Increase RATE control and decrease PULSE LENGTH control until a maximum rate and minimum pulse length are obtained without relay chatter. This process may take an hour or more for some tubes.
7. Allow instrument to run at maximum rate and minimum length for approximately twenty-four hours. Observe output pulse. If pulse is unsatisfactory due to excessive jitter or slow rise or decay time, allow to run an additional twenty-four hours. Again observe pulse. If, after seventy-two hours of operation, the output pulse is still unsatisfactory and the thyratron is known to be the cause of the trouble, try another replacement thyratron.

4-5 REPLACEMENT OF LOAD RESISTOR R21 AND R22

The resistors used for R21 and R22 may be any of several different types. A replacement resistor need not be identical, however, it must be non-inductive such as the deposited-carbon or metalized-film types. The resistor must have not less than a 5 watt dissapation rating.and should be within 5% of the value shown on the schematic diagram.

Parallel combinations of lower wattage resistors may be used successfully, however, lead and component length should be kept as short as possible.

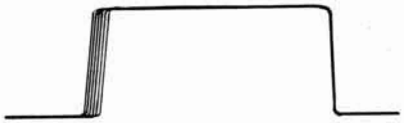
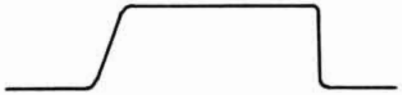
When R21 is replaced by a single, cylindrical resistor, the replacement should be mounted so its axis is horizontal and parallel to the side of the instrument.

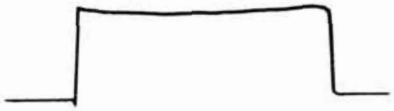
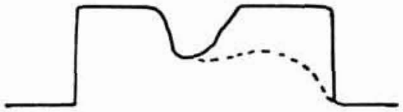
Replacement resistors for R21 and R22 may be procured from Hewlett-Packard Company. When possible, parts order should be accompanied by serial number of instrument to be serviced.

4-6 TROUBLE SHOOTING CHART

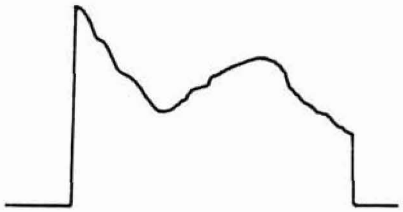
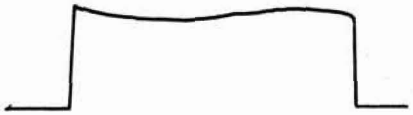
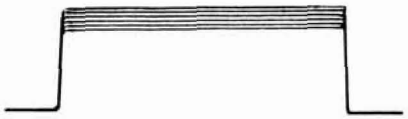
The following trouble shooting chart is a list of observed symptoms. The solutions for each symptom are listed in order of expected probability. Each suggested remedy is followed by a note giving cautions and checks that should be made following replacement of a component. When no caution or check is listed, the component may be replaced without other than normal precautions. Dial calibrations will usually be inaccurate following a tube change within a multivibrator circuit. If a tube is removed for checking and is not found faulty, it should be returned to the same socket.

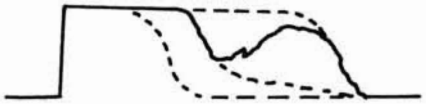
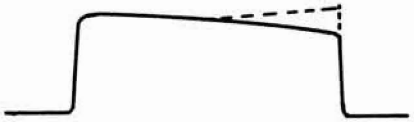
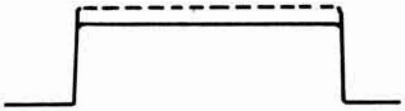
TROUBLE SHOOTING CHART FOR MODEL 212A PULSE GENERATOR

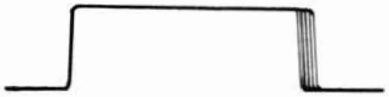
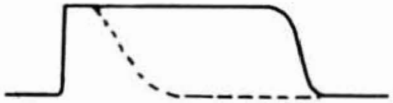
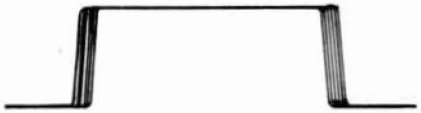
SYMPTOM	DEFECTIVE COMPONENT	SUGGESTIONS - CAUTIONS - CHECKS - ETC.
1. RELAY CHATTER	V6	Replace V6 or interchange V6 and V16. Check PULSE LENGTH calibration and pulse shape.
	V104	Replace V104. Check PULSE RATE calibration.
	V105	Replace V105. Check maximum pulse delay.
	V106	Replace V106.
	SHORTED CAPACITOR IN PULSE LINE	Replace defective capacitor. Check maximum pulse length.
2. JITTER ON LEADING EDGE ONLY OF OUTPUT PULSE 	V6	Replace V6. Check rise time and PULSE LENGTH calibration.
	V104) CR104)	Not likely to occur.
3. SLOW RISE TIME 	V6	Replace V6. Check rise time and PULSE LENGTH calibration.
4. NO PULSE (SYNC OUT PULSE AVAILABLE)	V6	Replace V6 or exchange V6 and V16 for trial. Check pulse shape and length.

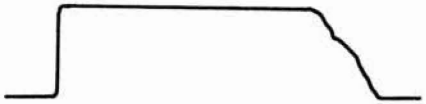
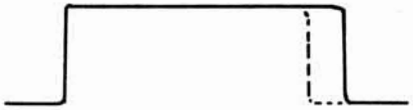
	V1	Replace V1.
	V2	Replace V2.
	L3	Replace L3.
	V105	Replace V105. Check maximum delay and 'Zero' position of control.
	V106	Replace V106.
	C135, C138	Replace defective capacitor in delay line.
5. OVERSHOOT ON LEADING EDGE 	V3	V3 may effect the very small spike on top of leading edge.
	V9	V9 may effect the 1/2 to 1 microsecond hump on top following leading edge.
	C31	C31 may be as high as 30 $\mu\mu$f to reduce various forms of overshoot.
6. DETERIORATION OF PULSE TOP 	V1	Replace V1.
	V2	Replace V2.
	V6	Check V6.
	RELAY	Clean contacts on relay RL-1.
	L2	Replace L2.)) Not likely to occur
	L3	Replace L3.)
	V104	Check pulse rate calibration, may be free running at very high rate.

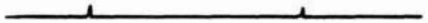
TROUBLE SHOOTING CHART (Cont'd)

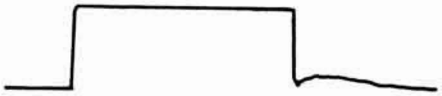
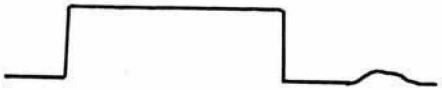
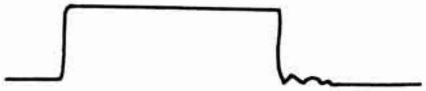
SYMPTOM	DEFECTIVE COMPONENT	SUGGESTIONS - CAUTIONS - CHECKS - ETC.
7. UNCLIPPED PULSE, HIGH AMPLITUDE PEAKS 	R30 V7 V9	R30 burns open if V7 or V9 shorts, resulting in an unclipped output pulse. Replace defective V7 or V9 and R30.
8. HUMPED TOP OF PULSE AT RATED OUTPUT 	V7	Replace V7. Check flatness of pulse top.
9. ENLARGED TRACE OF TOP OF PULSE 	V17	Replace V17. Check regulated voltage per instruction book. Any cause of high ripple from V17A can have this effect.
	V15	Replace V15. Check regulated voltage per instruction book.
	V11	Replace V11.

10. TOP OF PULSE ROLLS OFF PREMATURELY BETWEEN 1 and 6 µseconds 	C135) C136) C137) C138)	Replace defective capacitor in pulse delay line.
11. EXCESSIVE SLOPE ON TOP OF PULSE 	R30 V11 C5	Pad value of R30 to give optimum pulse level for both low and high rates. Value varies between 50 and 100 ohms. Replace V11) occurs with Replace C5) old components
12. VARIATION OF PULSE AMPLITUDE WITH CHANGE IN RATE OR LENGTH 	V17 V15 R51	Replace V17. Check maximum positive pulse amplitude. Replace V15. Check maximum positive pulse amplitude. Adjust value of R51 to give minimum amplitude variation with changes in rate.

SYMPTOM	DEFECTIVE COMPONENT	SUGGESTIONS - CAUTIONS - CHECKS - ETC.
13. JITTER ON TRAILING EDGE ONLY OUTPUT PULSES	V16	Replace V16. Check leading edge of output pulse and PULSE LENGTH calibration.
	V108	Replace V108. Check PULSE LENGTH calibration.
	V8	Replace V8, check trailing edge of output pulse.
	CR105	Replace CR105.
	CR106	Only as last resort change this crystal as it may require calibration of another PULSE LENGTH dial.
14. SLOW DECAY TIME 	V16	Replace V16 and check trailing edge of output pulse and PULSE LENGTH calibration.
	V8	Replace V8 and check trailing edge of output pulse and PULSE LENGTH calibration.
15. JITTER ON BOTH EDGES OF OUTPUT PULSE	V101	Replace V101. Check zero and maximum pulse advance and microphonics.
	V105	Replace V105. Check zero and maximum pulse delay and microphonics.
	V104	Replace V104. Check PULSE RATE calibration.
	V106	Replace V106.
	C103	Coupling capacitor C139 (C103) may be connected in two different positions. Either position may be used. (See schematic diagrams).

		The best position for a particular instrument is the one which gives least jitter. If plate to plate coupling is used, C103 must be approximately 50 μμfd. If plate to cathode coupling is used, C103 must be 30 μμfd.
	CR102	Replace CR102. Check maximum pulse delay.
	CR103	Replace CR103.
16. NO LENGTH CONTROL, PULSE ROLLS OFF AT 10.5 TO 11 μsecs.	V16	Replace V16. Check trailing edge of output pulse and PULSE LENGTH calibration.
	V8	Replace V8. Check trailing edge of output pulse.
	V108	Replace V108. Check PULSE LENGTH calibration.
	V109	Replace V109.
	V107	Replace V107.
17. DRIFT OF PULSE LENGTH FOLLOWING CHANGE IN PULSE RATE	V6	Replace V6. Check rise time and PULSE LENGTH calibration.
	V16	Replace V16. Check trailing edge of output pulse and PULSE LENGTH calibration.
	V108	Replace V108. Check PULSE LENGTH calibration.
	V109	Replace V109.
	V8	Replace V8. Check trailing edge of output pulse.
	V107	Replace V107. Check PULSE LENGTH calibration.
	CR106	Only as last resort replace this crystal as it may require calibration of a new PULSE LENGTH dial.
	CR105	Replace CR105.

SYMPTOM	DEFECTIVE COMPONENT	SUGGESTIONS - CAUTIONS - CHECKS - ETC.
18. NO PULSE VISIBLE - TRIGGER PULSE VISIBLE	V11 or power source for V11	Replace V11. Check maximum pulse amplitude. Replace defective component in power supply. Check maximum pulse amplitude and regulated supply voltage output per instruction manual.
	R21	Replace R21.
	R22	Replace R22.
19. AMPLITUDE OF NEG PULSE HIGHER THAN THAT OF POSITIVE PULSE	R22 In instruments having two parallel 100 ohm resistors for R22, check value of resistance	Replace defective resistor.
20. NO SYNC OUT PULSE	V102	Replace V102.
	V101	Replace V101. Check zero and maximum advance and microphonics.
	CR101	Replace CR101. Check SYNC OUT pulse.
	T101	Check winding continuity of T101. Following replacement, check SYNC OUT pulse shape.
	S101 switch circuitry, shielded cables, etc.	Check continuity and resistance to ground at points in sync output circuit.
21. INSUFFICIENT PULSE ADVANCE	V101	Replace V101. Check maximum advance obtainable, position of 0 advance on PULSE POSITION control and microphonics.

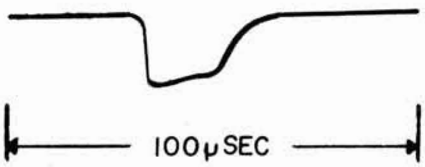
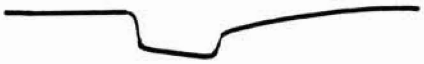
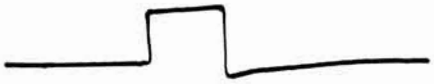
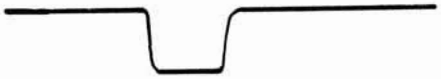
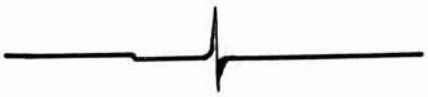
22. INSUFFICIENT PULSE DELAY	V105	Replace V105. Check maximum pulse delay, position of '0' delay on PULSE POSITION control and microphonics.
23. INSUFFICIENT PULSE AMPLITUDE	R35	With AMPLITUDE control set to maximum, adjust R35 to give 60 volt output pulse.
24. HUMP ON BASELINE FOLLOWING AND ATTACHED TO OUTPUT PULSE 	V11	Replace V11.
25. HUMP ON BASELINE FOLLOWING AND DETACHED FROM OUTPUT PULSE 	V6	Replace V6. Check leading edge of output pulse and PULSE LENGTH calibration.
26. INACCURATE RATE CALIBRATION	R125	Tolerances of high resistance potentiometers are wide. The potentiometer selected will determine calibration accuracy.
27. RINGING ON BASELINE, FOLLOWING REPLACEMENT OF TRANSFORMER T103 	T103	Install 220 ohm, 1/2 watt resistor in series with grid of V16.

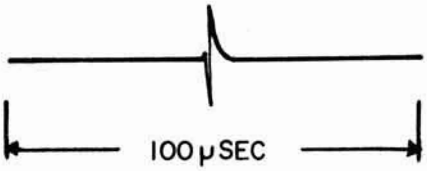
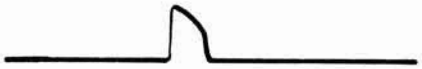
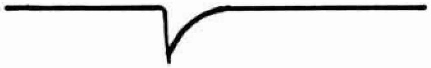
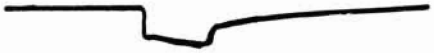
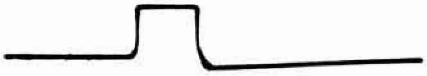
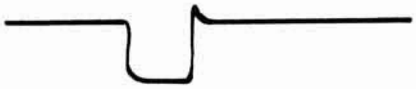
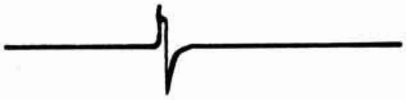
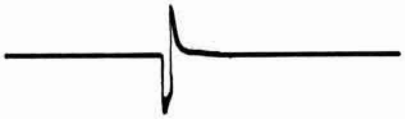
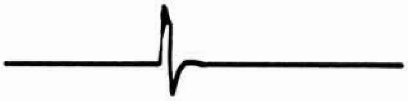
4-7

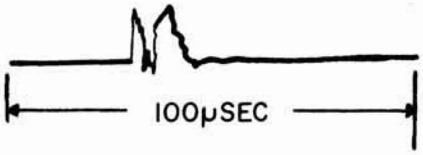
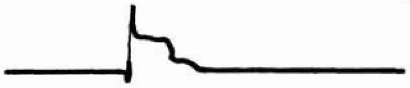
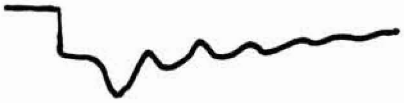
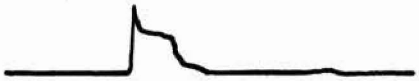
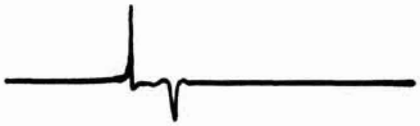
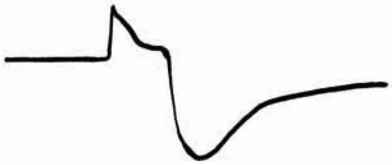
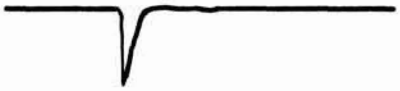
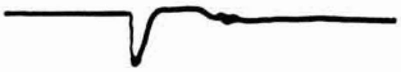
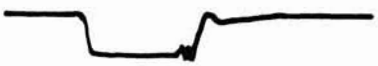
WAVEFORM DATA

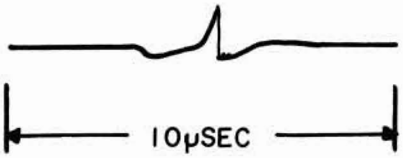
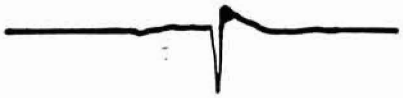
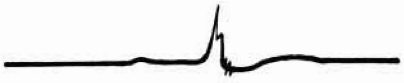
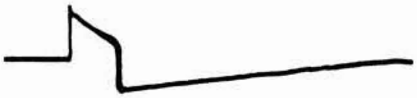
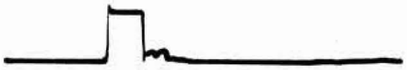
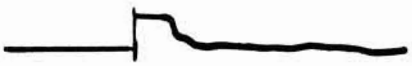
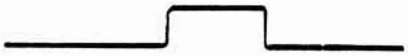
The following waveforms may be observed at various points throughout the circuits. The points selected are those most useful and provide a very nearly complete picture of signal process from pulse initiation to pulse completion. Small variations in pulse shape may be expected, particularly with degree of overshoot, and depending on oscilloscope sweep speed used. The newer type pulse transformers used in instruments following serial 1439 develop waveshapes similar to, but not identical with, the waveshapes produced by the earlier pulse transformers.

The leading or trailing edges of the observed pulses are the actual triggering devices, not the bodies. Pulse timing multivibrators, V101, V105 and V108 are 'one shot' types whose pulse length (time from leading to trailing edge) is the time lapse desired. A leading edge is simultaneous with the trigger pulse from the preceding circuit. The trailing edge becomes the trigger pulse for the following circuit.

	POINT OF MEASUREMENT	APPROX. VOLTAGE	µ SEC. LENGTH	WAVEFORM
1.	Pin 6 of V104b	260V-	100	
2.	Pin 1 of V101a	126V-	100	
3.	Pin 6 of V101b	76V+	100	
4.	Pin 1 of V102a	170V-	100	
5.	Pin 7 of V102b	78V+	100	

	POINT OF MEASUREMENT	APPROX. VOLTAGE	μ SEC. LENGTH	WAVEFORM
6.	Pin 6 of V102b	162V-	100	
7.	SYNC OUT (positive)	58V+	10	
8.	C118, output side	121V-	100	
9.	Pin 1 of V105a	84V-	100	
10.	Pin 6 of V105b	76V+	100	
11.	Pin 1 of V106a	162V-	100	
12.	Pin 7 of V106b	70V+	100	
13.	Pin 6 of V106b	185V-	100	
14.	Pin 2 of V107b	350V+	100	

	POINT OF MEASUREMENT	APPROX. VOLTAGE	µ SEC. LENGTH	WAVEFORM
15.	Delay line, input	420V+	100	
16.	Delay line, output	480V+	100	
17.	Plate cap of V6	-900 to -1500 total volts.	100	
18.	Pin 2 or 4 of V6	500V+	100	
19.	Pin 7 of V10a	280V+ 100V-	10	
20.	Pin 7 of V107a	59V+	10	
21.	Pin 6 of V107a	216V-	10	
22.	Pin 2 of V108a	34V-	10	
23.	Pin 6 of V108b	112V-	10	

	POINT OF MEASUREMENT	APPROX. VOLTAGE	µ SEC. LENGTH	WAVEFORM
24.	Pin 2 of V109a	66V+	10	
25.	Pin 1 of V109a	160V-	10	
26.	Pin 7 of V109a	218V+	10	
27.	Plate cap of V16	345V+	100	
28.	Pins 1, 2, 5 and 6 of V8	380V+	100	
29.	Pin 1 of V11	350V+	100	
30.	Pins 3 and 6 of V11 (positive pulse output)	50V+	100	

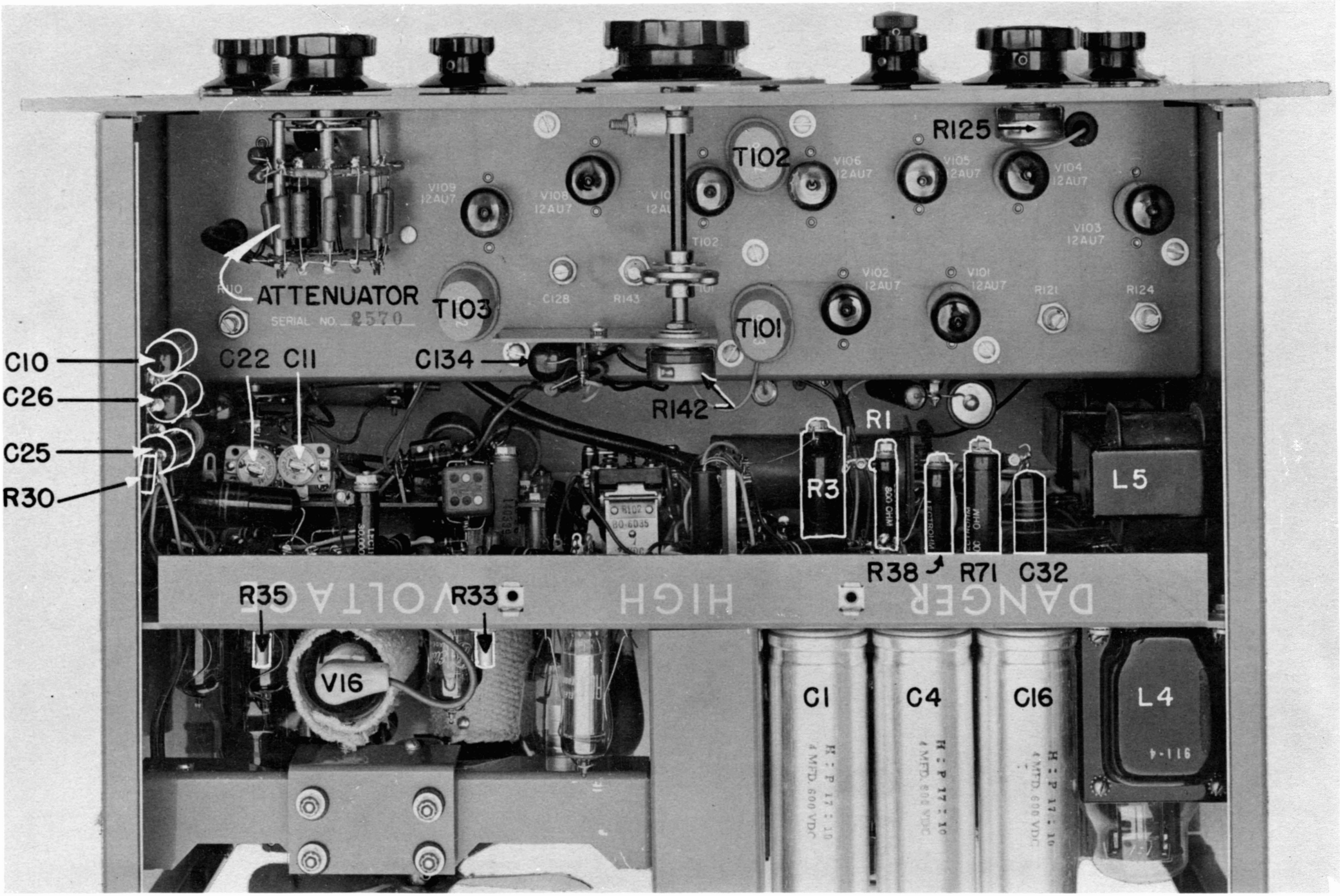

R125
T102
V109 12AU7
V108 12AU7
V106 12AU7
V105 12AU7
V104 12AU7
V103 12AU7
V102 12AU7
V101 12AU7
ATTENUATOR
SERIAL NO. 2570
T103
T101
C128
R143
R121
R124
C10
C26
C25
R30
C22
C11
C134
R142
R1
R3
R38
R71
C32
L5
DANGER HIGH VOLTAGE
R35
R33
V16
C1
C4
C16
L4

Fig. 4-1 Pulse Generator, Typical Top View, Cover Removed

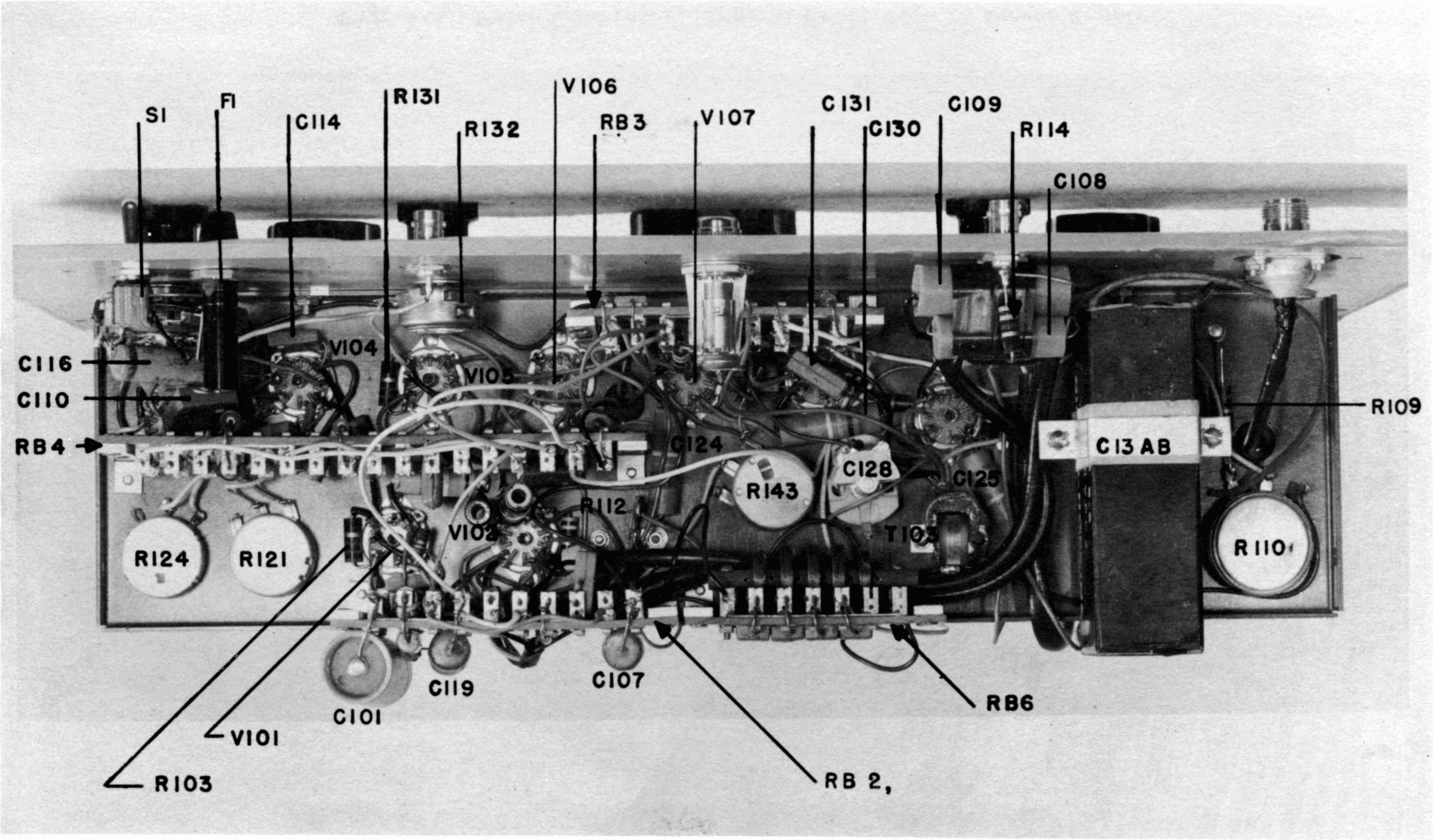

S1
F1
C114
R131
R132
V106
RB3
V107
C131
C130
C109
R114
C108
C116
C110
RB4
V104
V105
C124
R109
C13 AB
R143
C128
C125
R112
T105
R110
R124
R121
V102
C119
C107
C101
V101
RB6
R103
RB 2,

Fig. 4-2 Pulse Generator, Typical Bottom View, Pulse Timing Section

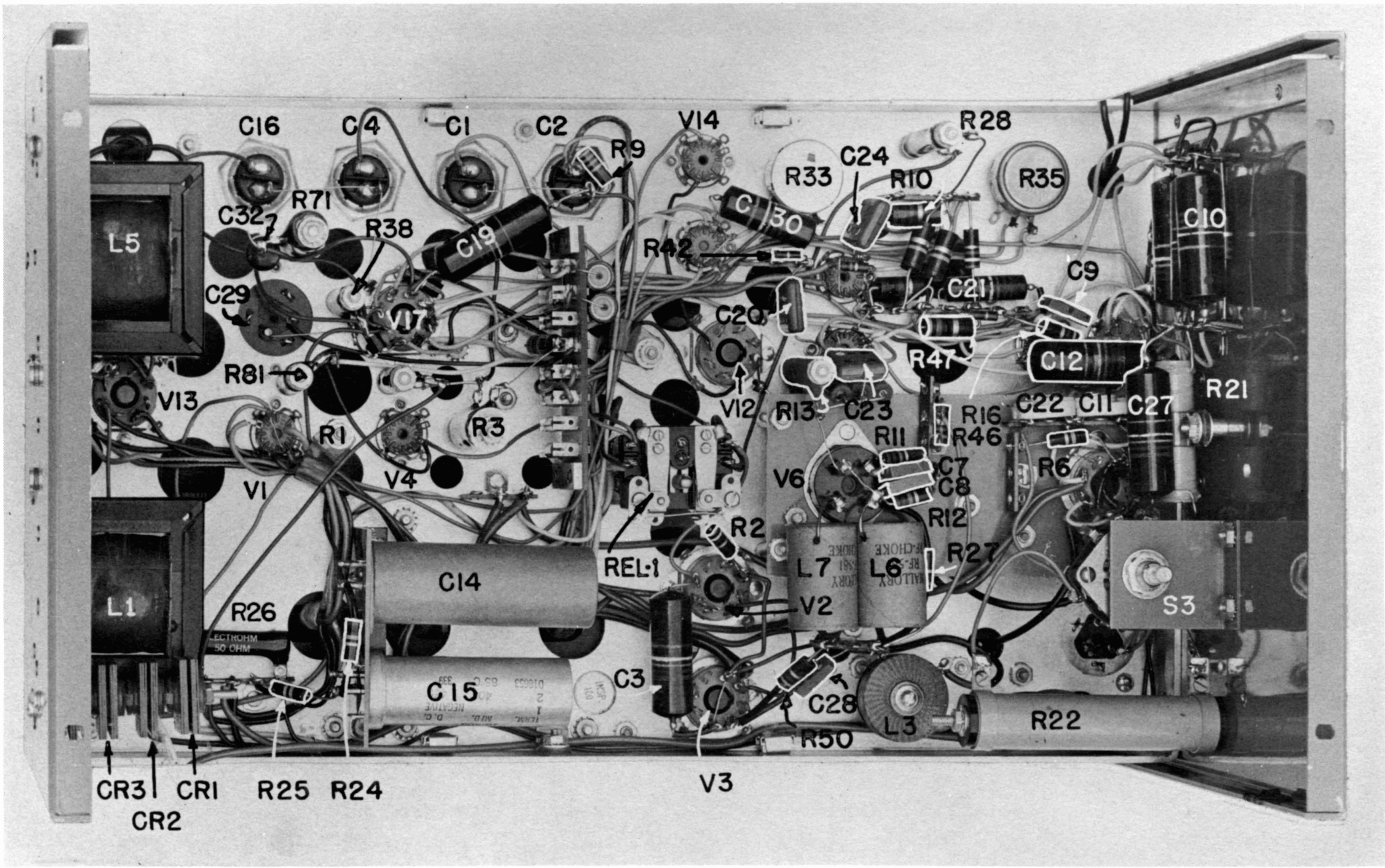

C16
C4
C1
C2
V14
R28
R9
R33
C24
R10
R35
C32
R71
R38
C19
C30
R42
C10
C29
V17
C21
C9
C20
R47
C12
R81
V13
V12
R13
C23
R16
C22
C11
C27
R21
R46
R11
R1
R3
V6
C7
R6
C8
V1
V4
R12
R2
R27
REL-1
L5
C14
L7
L6
V2
S3
L1
R26
C3
C15
C28
R22
L3
R50
CR3
CR1
R25
R24
V3
CR2

Fig. 4-3 Pulse Generator, Typical Front View of Power Supply and Pulse Generating Sections (Removed)

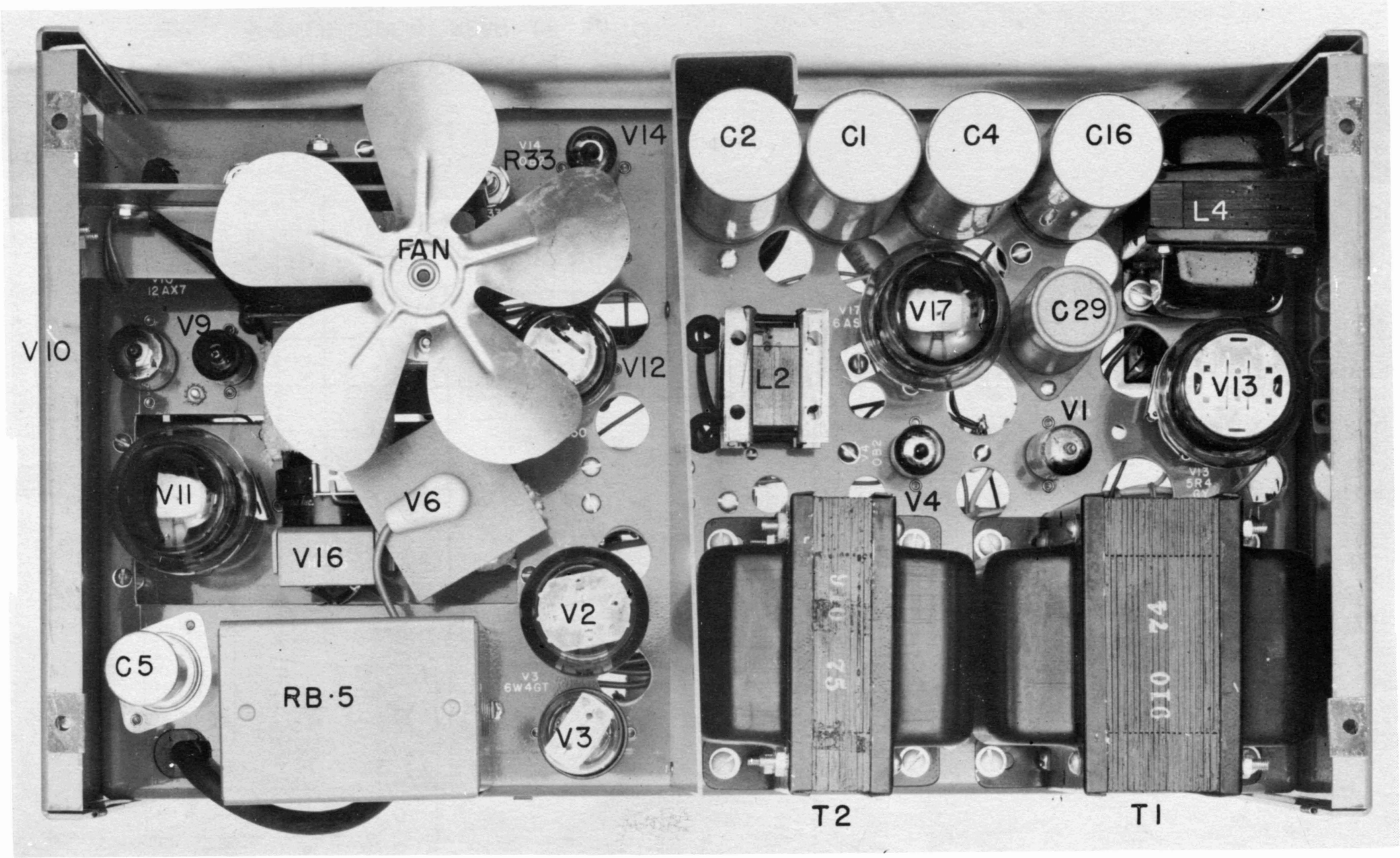

FAN
V14
R33
C2
C1
C4
C16
L4
V10
12 AX7
V9
V12
L2
V17
C29
V13
V1
V11
V6
V4
V16
V2
C5
RB·5
V3
6W4GT
T2
T1

Fig. 4-4 Pulse Generator, Typical Rear View of Power Supply and Pulse Generating Sections (Removed)

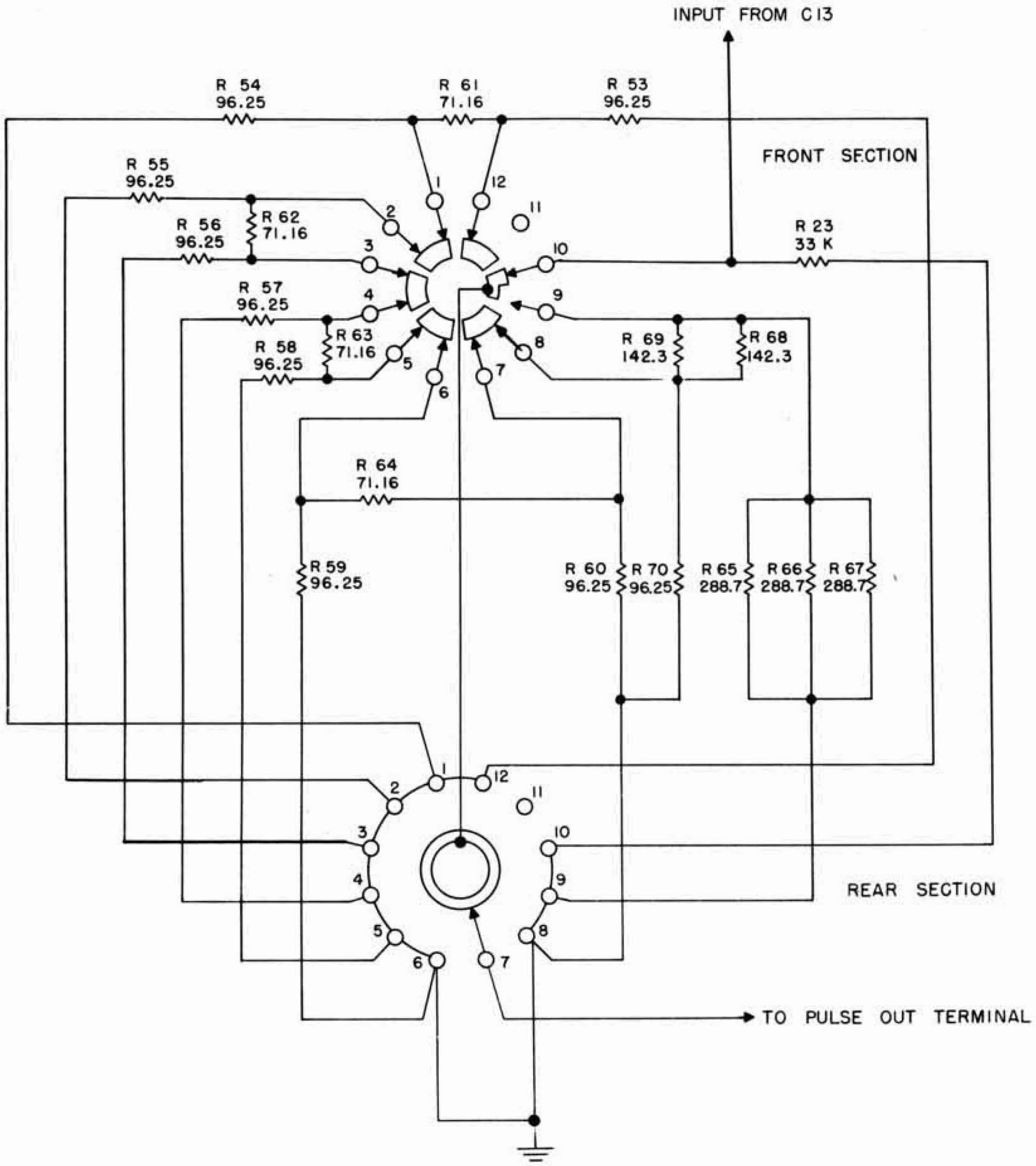
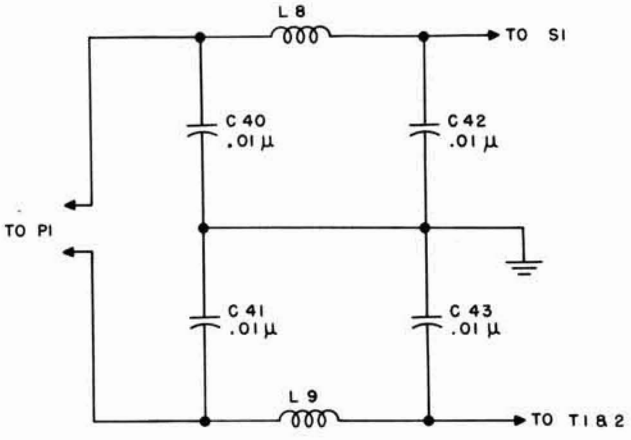

INPUT FROM C13
R 54
96.25
R 61
71.16
R 53
96.25
FRONT SECTION
R 55
96.25
R 62
71.16
R 56
96.25
R 57
96.25
R 63
71.16
R 58
96.25
R 23
33 K
R 69
142.3
R 68
142.3
R 64
71.16
R 59
96.25
R 60
96.25
R 70
96.25
R 65
288.7
R 66
288.7
R 67
288.7
1
2
3
4
5
6
7
8
9
10
11
12
REAR SECTION
TO PULSE OUT TERMINAL

Fig. 4-5 OUTPUT ATTENUATOR DETAIL

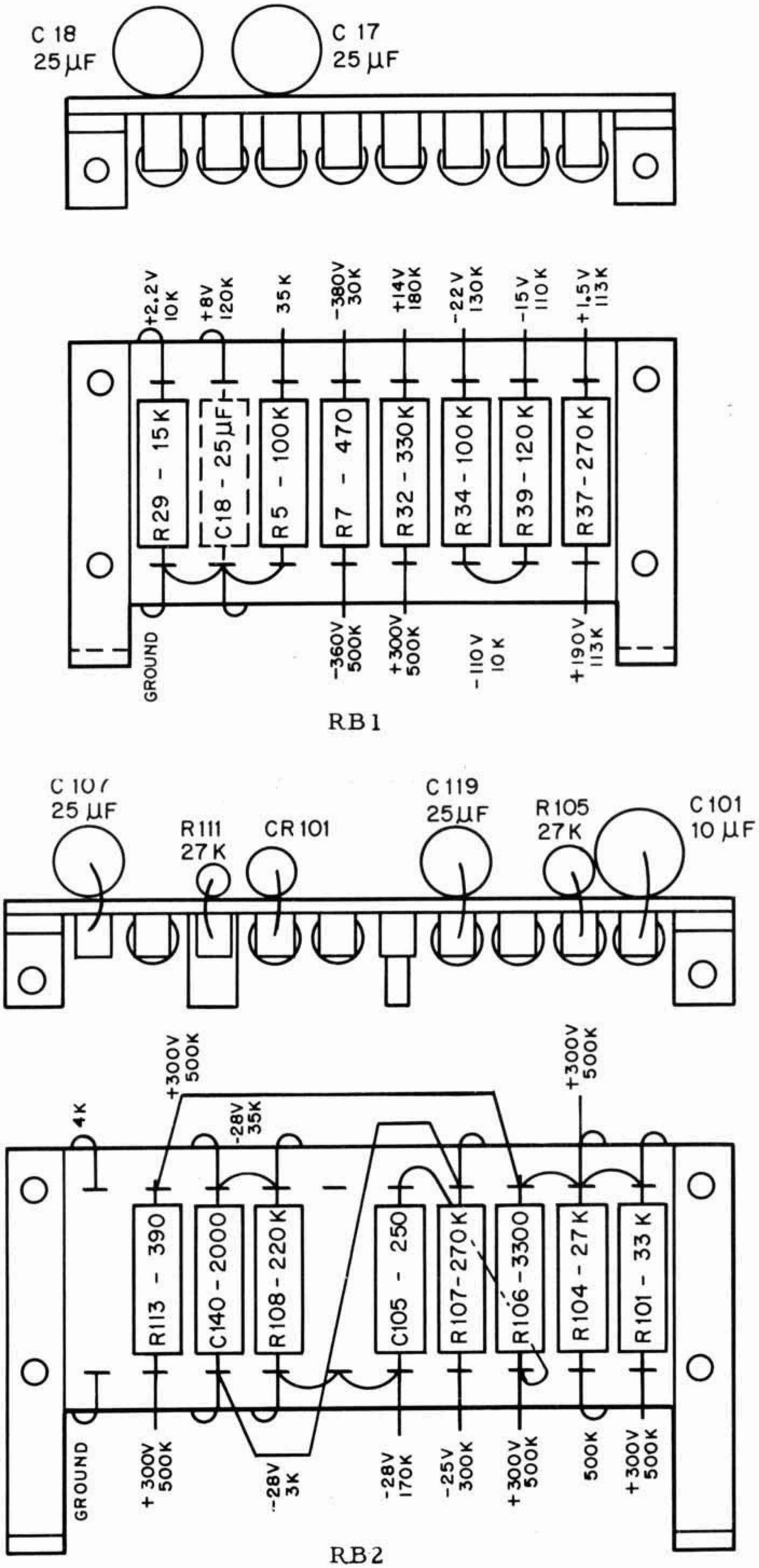
VIEWED FROM REAR OF SWITCH

ATTENUATION - ODB.


L 8
TO S1
C 40
.01 μ
C 42
.01 μ
TO P1
C 41
.01 μ
C 43
.01 μ
L 9
TO T1 & 2

POWER LINE FILTER DETAIL

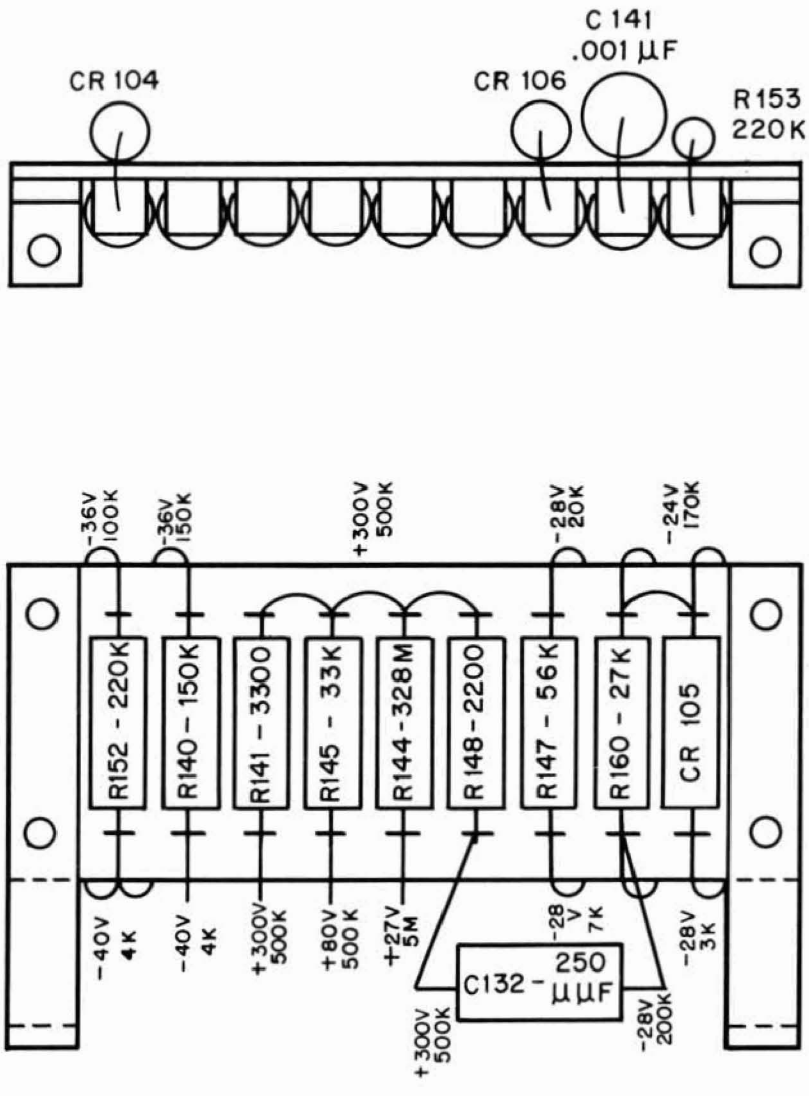
THE POWER LINE FILTER IS NOT REQUIRED ON INSTRUMENTS WHERE T1 AND T2 CONTAIN INTERNAL ELECTROSTATIC SHIELDS.


C 18
25 μF
C 17
25 μF
+2.2V
10K
+8V
120K
35 K
-380V
30K
+14V
180K
-22V
130K
-15V
110K
+1.5V
113K
R29 - 15K
C18 - 25μF
R5 - 100K
R7 - 470
R32 - 330K
R34 - 100K
R39 - 120K
R37 - 270K
GROUND
-360V
500K
+300V
500K
-110V
10K
+190V
113K
C 107
25 μF
R111
27K
CR101
C119
25μF
R105
27K
C101
10 μF
4K
+300V
500K
-28V
35K
+300V
500K
R113 - 390
C140 - 2000
R108 - 220K
C105 - 250
R107 - 270K
R106 - 3300
R104 - 27K
R101 - 33K
GROUND
+300V
500K
-28V
3K
-28V
170K
-25V
300K
+300V
500K
500K
+300V
500K

RB1

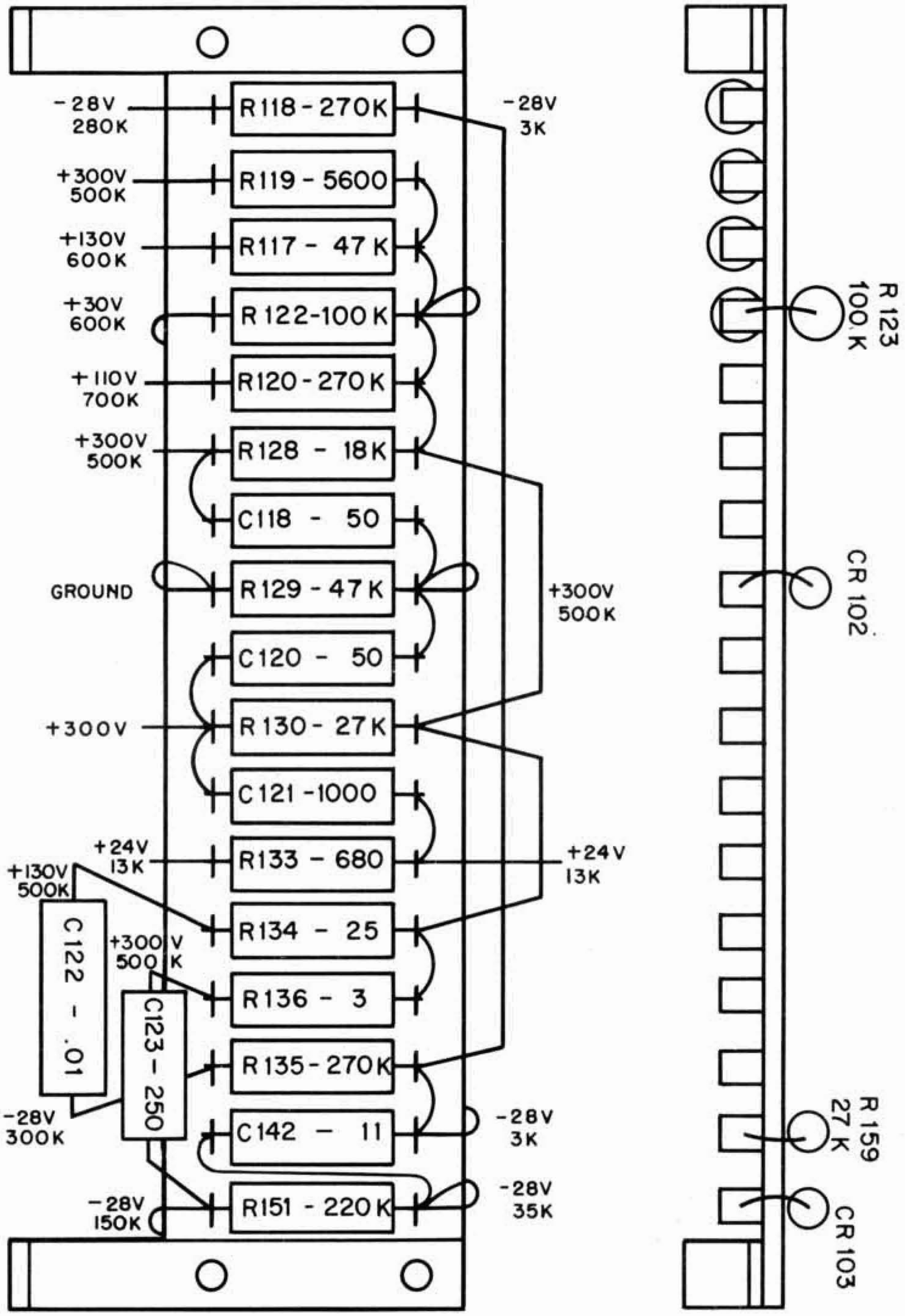
RB2

Fig. 4-6 Typical Resistor Board Details


C 141
.001 μF
CR 104
CR 106
R153
220K
-36V
100K
-36V
150K
+300V
500K
-28V
20K
-24V
170K
R152 - 220K
R140 - 150K
R141 - 3300
R145 - 33K
R144-328M
R148-2200
R147 - 56K
R160 - 27K
CR 105
-40V
4K
-40V
4K
+300V
500K
+80V
500K
+27V
5M
-28
V
7K
-28V
3K
C132 - 250 μμF
+300V
500K
-28V
200K

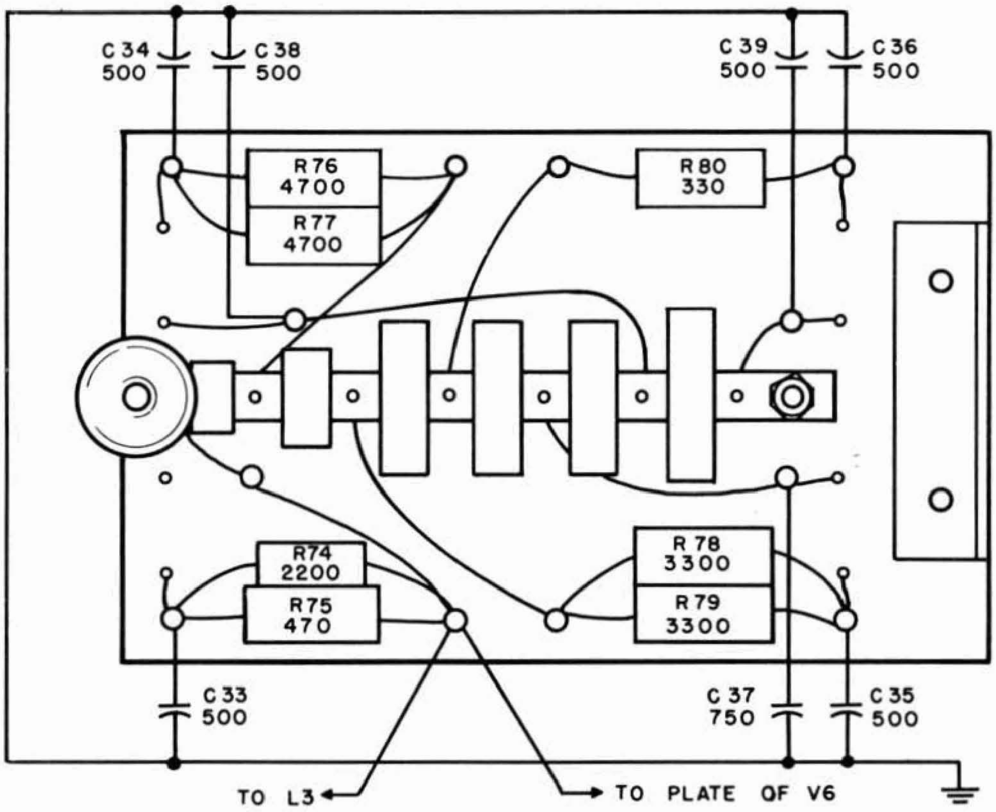
RB3

Fig. 4-7 Typical Resistor Board Details

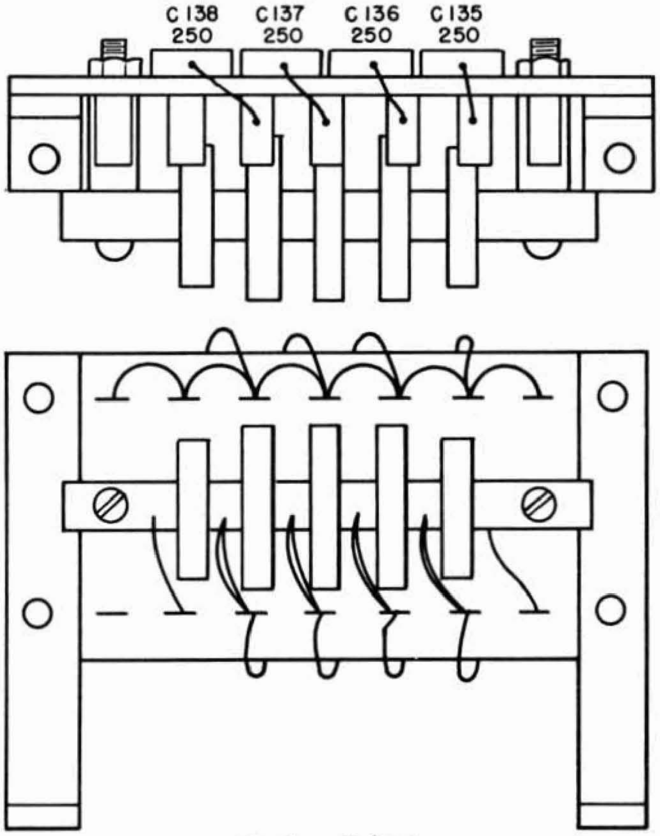

-28V
280K
R118-270K
-28V
3K
+300V
500K
R119-5600
+130V
600K
R117-47K
+30V
600K
R122-100K
+110V
700K
R120-270K
+300V
500K
R128-18K
C118-50
GROUND
R129-47K
+300V
500K
C120-50
+300V
R130-27K
C121-1000
+24V
13K
R133-680
+24V
13K
+130V
500K
R134-25
C122-.01
+300V
500K
R136-3
C123-250
R135-270K
-28V
300K
C142-11
-28V
3K
-28V
150K
R151-220K
-28V
35K
R 123
100 K
CR 102
R 159
27 K
CR 103

RB4.

Fig. 4-8 Typical Resistor Board Details

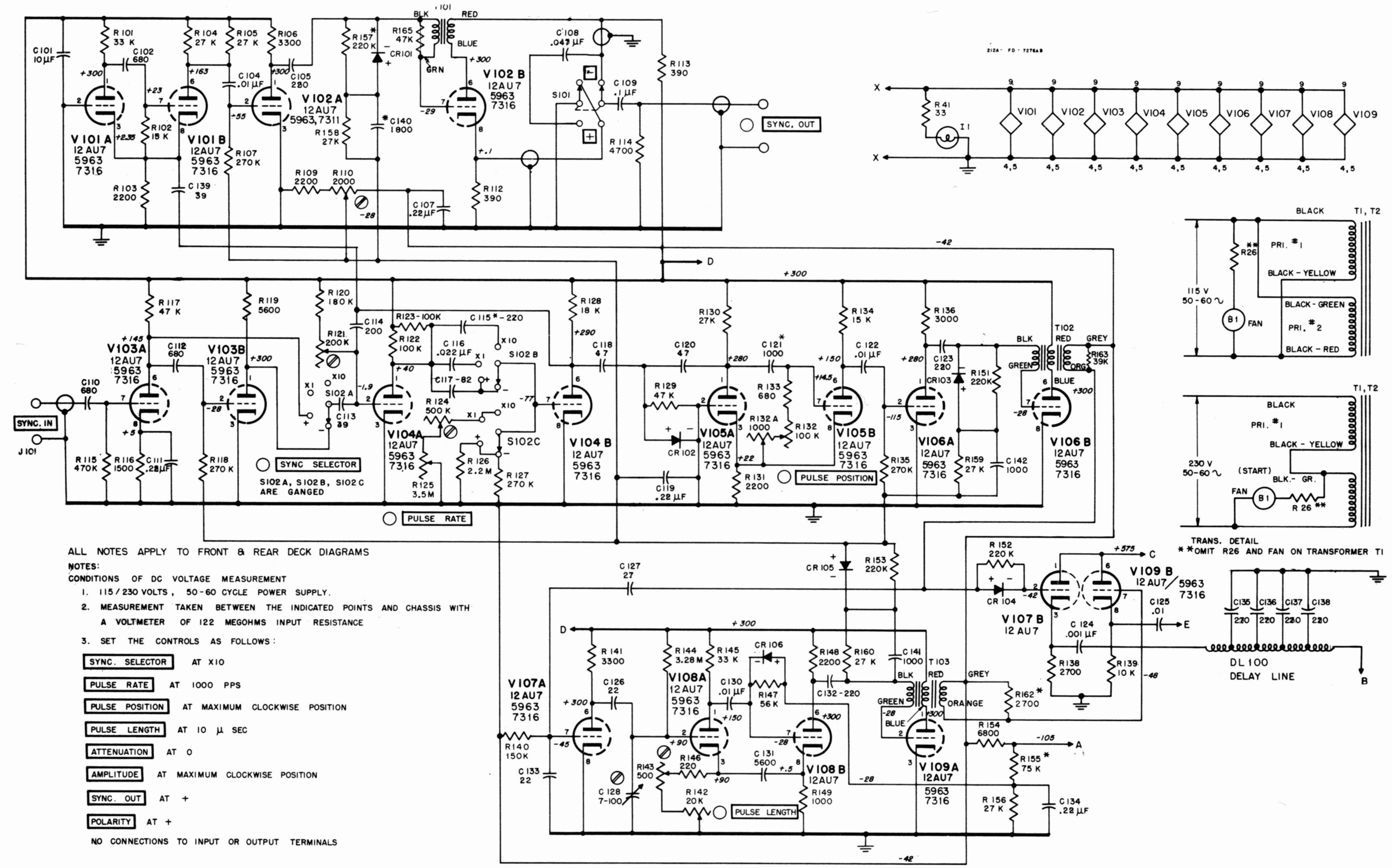

C 34
500
C 38
500
C 39
500
C 36
500
R 76
4700
R 77
4700
R 80
330
R74
2200
R 75
470
R 78
3300
R 79
3300
C 33
500
C 37
750
C 35
500
TO L3
TO PLATE OF V6

Pulse Forming Line
RB5


C 138
250
C 137
250
C 136
250
C 135
250

Delay Line
RB6

Fig. 4-9 Typical Resistor Board Details



212A - FD - T276AB
C101 10µF
R101 33K
C102 680
R104 27K
R105 27K
R106 3300
C104 .01µF
C105 280
V101A 12AU7 5963 7316
V101B 12AU7 5963 7316
R102 15K
R103 2200
C139 39
R107 270K
V102A 12AU7 5963,7311
R157 220K
R158 27K
C140 1800
CR101
R165 47K
T101
BLK
RED
BLUE
GRN
V102B 12AU7 5963 7316
R109 2200
R110 2000
C107 .22µF
R112 390
C108 .047µF
S101
C109 .1µF
R114 4700
R113 390
SYNC. OUT
R41 33
I1
V101 V102 V103 V104 V105 V106 V107 V108 V109
X
9
4,5
D
+300
-42
R117 47K
R119 5600
R120 180K
R121 200K
V103A 12AU7 5963 7316
V103B 12AU7 5963 7316
C112 680
C110 680
SYNC. IN
J101
R115 470K
R116 1500
C111 .22µF
R118 270K
C113 39
S102A
S102B
S102C
X1
X10
C114 200
R123-100K
C115*-220
R122 100K
C116 .022µF
C117-82
R124 500K
V104A 12AU7 5963 7316
R125 3.5M
R126 2.2M
R127 270K
R128 18K
C118 47
V104B 12AU7 5963 7316
SYNC SELECTOR
S102A, S102B, S102C ARE GANGED
PULSE RATE
R130 27K
C120 47
R129 47K
CR102
V105A 12AU7 5963 7316
C119 .22µF
R131 2200
C121* 1000
R133 680
R132A 1000
R132 100K
PULSE POSITION
R134 15K
C122 .01µF
V105B 12AU7 5963 7316
R135 270K
R136 3000
C123 220
CR103
R151 220K
V106A 12AU7 5963 7316
R159 27K
C142 1000
T102
GREEN
ORG
GREY
R163 39K
V106B 12AU7 5963 7316
BLACK
T1, T2
PRI. #1
R26**
BLACK-YELLOW
BLACK-GREEN
PRI. #2
BLACK-RED
115V 50-60 ~
B1 FAN
230V 50-60 ~
(START)
BLK.-GR.
R26**
TRANS. DETAIL
**OMIT R26 AND FAN ON TRANSFORMER T1
C127 27
CR105
R153 220K
R152 220K
CR104
+575
C
V107B 12AU7
V109B 12AU7/5963 7316
C125 .01
E
C124 .001µF
R138 2700
R139 10K
C135 220
C136 220
C137 220
C138 220
DL100 DELAY LINE
B
R141 3300
C126 22
V107A 12AU7 5963 7316
R140 150K
C133 22
C128 7-100
R144 3.28M
R145 33K
V108A 12AU7 5963 7316
C130 .01µF
CR106
R147 56K
R146 220
R143 500
R142 20K
PULSE LENGTH
C131 5600
V108B 12AU7
R149 1000
R148 2200
R160 27K
C141 1000
C132-220
T103
ORANGE
R162* 2700
V109A 12AU7 5963 7316
R154 6800
R155* 75K
R156 27K
C134 .22µF
A
-105

ALL NOTES APPLY TO FRONT & REAR DECK DIAGRAMS

NOTES:

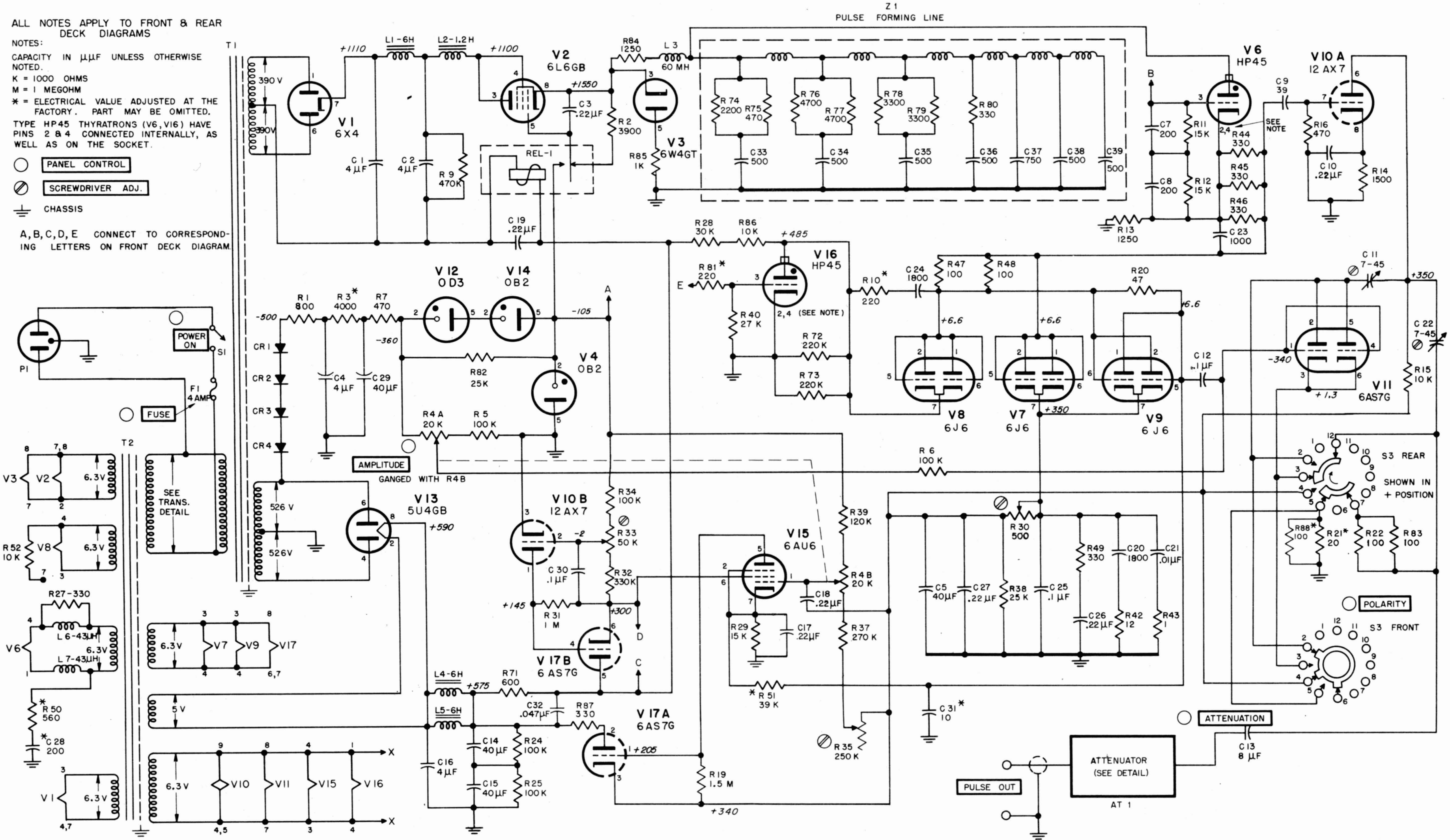
CONDITIONS OF DC VOLTAGE MEASUREMENT

1. 115/230 VOLTS, 50-60 CYCLE POWER SUPPLY.
2. MEASUREMENT TAKEN BETWEEN THE INDICATED POINTS AND CHASSIS WITH A VOLTMETER OF 122 MEGOHMS INPUT RESISTANCE
3. SET THE CONTROLS AS FOLLOWS:

SYNC. SELECTOR	AT X10
PULSE RATE	AT 1000 PPS
PULSE POSITION	AT MAXIMUM CLOCKWISE POSITION
PULSE LENGTH	AT 10 µ SEC
ATTENUATION	AT 0
AMPLITUDE	AT MAXIMUM CLOCKWISE POSITION
SYNC. OUT	AT +
POLARITY	AT +

NO CONNECTIONS TO INPUT OR OUTPUT TERMINALS

hp Model 212A Front Deck


Z1
PULSE FORMING LINE
T1
390 V
390V
+1110
L1-6H
L2-1.2H
+1100
V2
6L6GB
+1550
C3 .22µF
V1
6X4
C1 4µF
C2 4µF
R9 470K
REL-1
R84 1250
L3 60 MH
R2 3900
V3 6W4GT
R85 1K
R74 2200
R75 470
R76 4700
R77 4700
R78 3300
R79 3300
R80 330
C33 500
C34 500
C35 500
C36 500
C37 750
C38 500
C39 500
B
V6
HP45
C7 200
C8 200
R11 15K
R12 15 K
R13 1250
R44 330
R45 330
R46 330
C23 1000
SEE NOTE
C9 39
V10 A
12 AX7
R16 470
C10 .22µF
R14 1500
C19 .22µF
R28 30K
R86 10K
+485
V16
HP45
R81* 220
E
R40 27 K
(SEE NOTE)
R72 220 K
R73 220 K
R10* 220
C24 1800
R47 100
R48 100
R20 47
+6.6
+6.6
+6.6
V8 6J6
V7 6J6
V9 6J6
+350
C12 .1 µF
C11 7-45
+350
C22 7-45
-340
V11 6AS7G
+1.3
R15 10 K
P1
POWER ON
S1
F1 4 AMP
FUSE
V12 OD3
V14 OB2
R1 800
R3* 4000
R7 470
-500
-360
-105
A
CR1
CR2
CR3
CR4
C4 4µF
C29 40µF
R82 25K
V4 OB2
R4A 20 K
R5 100 K
AMPLITUDE
GANGED WITH R4B
R6 100 K
S3 REAR
SHOWN IN + POSITION
T2
V3
V2
6.3V
SEE TRANS. DETAIL
526 V
526V
V13 5U4GB
+590
V10 B 12 AX7
R34 100K
R33 50 K
C30 .1µF
R32 330K
+145
R31 1 M
+300
D
C
V17 B 6AS7G
V15 6AU6
R39 120K
R4B 20 K
C18 .22µF
R37 270 K
R29 15 K
C17 .22µF
R51* 39 K
R35 250 K
R30 500
C5 40µF
C27 .22 µF
R38 25 K
C25 .1 µF
R49 330
C20 1800
C21 .01µF
C26 .22µF
R42 12
R43 1
C31* 10
R88* 100
R21* 20
R22 100
R83 100
POLARITY
S3 FRONT
ATTENUATION
C13 8 µF
ATTENUATOR (SEE DETAIL)
AT 1
PULSE OUT
R52 10K
V8
6.3V
R27-330
L6-43µH
L7-43µH
V6
R50* 560
C28* 200
V7
V9
V17
V1
6.3V
L4-6H
+575
R71 600
C32 .047µF
R87 330
V17A 6AS7G
+205
L5-6H
C14 40µF
R24 100K
C15 40µF
R25 100K
C16 4µF
R19 1.5 M
+340
5 V
6.3V
V10
V11
V15
V16
X
X

ALL NOTES APPLY TO FRONT & REAR DECK DIAGRAMS

NOTES:

CAPACITY IN µµF UNLESS OTHERWISE NOTED.

K = 1000 OHMS

M = 1 MEGOHM

* = ELECTRICAL VALUE ADJUSTED AT THE FACTORY. PART MAY BE OMITTED.

TYPE HP45 THYRATRONS (V6, V16) HAVE PINS 2 & 4 CONNECTED INTERNALLY, AS WELL AS ON THE SOCKET.

○ PANEL CONTROL

⊘ SCREWDRIVER ADJ.

⏚ CHASSIS

A, B, C, D, E CONNECT TO CORRESPONDING LETTERS ON FRONT DECK DIAGRAM.

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hp Model 212A Rear Deck

SECTION V
TABLE OF REPLACEABLE PARTS

NOTE

Readily available standard-components have been used in this instrument, whenever possible. However, special components may be obtained from your local Hewlett-Packard representative or from the factory.

When ordering parts always include:

1. ⓗ Stock Number.
2. Complete description of part including circuit reference.
3. Model number and serial number of instrument.
4. If part is not listed give complete description, function, and location of part.

If there are any corrections for the Table of Replaceable Parts they will be listed on an Instruction Manual Change sheet at the front of this manual.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	STOCK NO.	#			
AT 1	Attenuator Assembly: output HP*	212A-19B	1			
B1	Fan Motor General Indust. Co.	314-43	1			
C1, 2	Capacitor: fixed, paper P* 4 µf ±10%, 1000 vdcw	17-54	4			
C3	Capacitor: fixed, paper dielectric, .22 µf ±10%, 400 vdcw CC*	16-48	11			
C4	Same as C1					
C5	Capacitor: fixed, electrolytic, 40 µf, 450 vdcw CC*	18-40HP	4			
C6	This circuit reference not assigned					
C7, 8	Capacitor: fixed, mica, 200 µµf ±10%, 500 vdcw V*	14-200	4			
C9	Capacitor: fixed, mica, 39 µµf ±10%, 500 vdcw V*	14-48	2			
C10	Same as C3					
C11	Capacitor: variable, ceramic dielectric, 7-45 µµf 500 vdcw L*	13-1	2			
C12	Capacitor: fixed, paper dielectric, 0.1 µf ±10%, 600 vdcw CC*	16-1	2			
C13	Capacitor: fixed, paper dielectric, 8 µf ±20%, 600 vdcw P*	17-25	1			
C14, 15	Same as C5					
C16	Same as C1					
C17, 18, 19	Same as C3					
C20	Capacitor: fixed, mica, 1800 µµf ±10%, 500 vdcw Z*	14-47	3			
C21	Capacitor: fixed, paper dielectric .01 µf, ±10%, 600 vdcw CC*	16-11	5			
C22	Same as C11					
C23	Capacitor: fixed, mica, 1000 µµf ±10%, 500 vdcw V*	14-11	5			
C24	Same as C20					
C25	Same as C12					
C26, 27	Same as C3					
C28	Same as C7 Electrical value adjusted at factory					
C29	Same as C5					
C30	Capacitor: fixed, paper dielectric, 0.1 µf, ±10%, 400 vdcw CC*	16-35	1			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	STOCK NO.	#			
C31	Capacitor: fixed, mica, 10 μμf, ±10%, 500 vdcw V* Electrical value adjusted at factory	14-10	1			
C32	Capacitor: fixed, paper dielectric, .047 μf, ±10%, 600 vdcw CC*	16-15	2			
C33 thru C36	Capacitor: fixed, mica, 500 μμf, ±5%, 2500 vdcw Z*	14-36	6			
C37	Capacitor: fixed, mica, 750 μμf, ±5%, 2500 vdcw Z*	14-37	1			
C38, 39	Same as C33					
C40 thru C100	These circuit references not assigned					
C101	Capacitor: fixed, electrolytic, 10 μf, ±50%, 450 vdcw X*	18-10	1			
C102	Capacitor: fixed, mica, 680 μμf, ±10%, 500 vdcw Z*	14-21	3			
C103	This circuit reference not assigned					
C104	Same as C21					
C105	Capacitor: fixed, mica, 220 μμf, ±10%, 500 vdcw V*	14-66	3			
C106	This circuit reference not assigned					
C107	Same as C3					
C108	Same as C32					
C109	Capacitor: fixed, paper dielectric, 0.1 μf, ±10%, 600 vdcw CC*	16-1	1			
C110	Same as C102					
C111	Same as C3					
C112	Same as C102					
C113	Same as C9					
C114	Same as C7					
C115	Capacitor: fixed, silver mica, 220 μμf, ±5%, 500 vdcw Z* Electrical value adjusted at factory	15-32	1			
C116	Capacitor: fixed, paper dielectric, .022 μf, ±10%, 600 vdcw CC*	16-12	1			
C117	Capacitor: fixed, mica, 82 μμf, ±10%, 500 vdcw V*	14-19	1			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	STOCK NO.	#			
C118	Capacitor: fixed, mica, 47 μμf, ±10%, 500 vdcw V*	14-67	2			
C119	Same as C3					
C120	Same as C118					
C121	Same as C23 - Electrical value adjusted at factory					
C122	Same as C121					
C123	Same as C105					
C124	Same as C23					
C125	Same as C21					
C126	Capacitor: fixed, mica, 22 μμf, ±10%, 500 vdcw Z*	14-61	2			
C127	Capacitor: fixed, mica, 27 μμf, ±10%, 500 vdcw V*	14-17	1			
C128	Capacitor: variable, air dielectric, 7.5 - 102.7 μμf AA*	12-12	1			
C129	This circuit reference not assigned					
C130	Same as C21					
C131	Capacitor: fixed, silver mica, 5600 μμf, ±1%, 300 vdcw A*	15-42	1			
C132	Same as C105					
C133	Same as C126					
C134	Same as C3					
C135 thru C138	Capacitor: fixed, mica, 270 μμf, ±10%, 500 vdcw V*	14-42	4			
C139	Capacitor: fixed, mica, 39 μμf, ±10%, 500 vdcw V*	14-48	1			
C140	Same as C20 Electrical value adjusted at factory					
C141, 142	Same as C23					
C143	This circuit reference not assigned					
CR1, 2, 3, 4	Rectifiers, selenium AA*	212-60	4			
CR5-100	These circuit references not assigned					
CR101, 103, 104, 105	Rectifier, crystal: germanium diode Transitron	212-G12	6			
CR102, CR106	Crystal, rectifier, diode BU*	212-G11A	2			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	℗ STOCK NO.	#			
DL100	Pulse delay line HP*	212A-60C	1			
DS1	Lamp, incandescent: .15 amp, 6-8V, #47 N*	211-47	1			
F1	Fuse, cartridge: 4 amp, 115V E* Fuse, cartridge: 2 amp, 230V E*	211-46 211-16	1			
J101, 102	Receptacle, BNC, RF connector, SYNC IN, SYNC OUT LL*	125-9	2			
L1	Reactor, filter: open frame Paeco	911-12	2			
L2	Reactor, pulse line charging Paeco	911-52	1			
L3	Choke, R.F., 60 µh HP*	522B-60B-1	1			
L4	Same as L1					
L5	Reactor, filter: 6h, enclosed frame Paeco	911-4	1			
L6, 7	Choke, R.F.: 43 µh J. E. Fast & Co.	48-6	2			
P1	Cable, power Elec. Cords Co.	812-106	1			
R1	Resistor: fixed, wirewound, 800 ohms, ±10%, 10 W S*	26-6	1			
R2	Resistor: fixed, composition, 3900 ohms, ±10%, 1 W B*	24-3900	1			
R3	Resistor: fixed, wirewound, 4000 ohms, ±5%, 20 W S* Electrical value adjusted at factory	27-7	1			
R4A, B	Resistor: variable, dual, 20,000 ohms/sect. BO*	210-68	1			
R5, 6	Resistor: fixed, composition, 100,000 ohms, ±10%, 1 W B*	24-100K	5			
R7	Resistor: fixed, composition, 470 ohms, ±10%, 2 W B*	25-470	1			
R8	This circuit reference not assigned					
R9	Resistor: fixed, composition, 470,000 ohms, ±10%, 1 W B*	24-470K	2			
R10	Resistor: fixed, composition, 220 ohms, ±10%, 2 W B* Electrical value adjusted at factory	25-220	1			
R11, 12	Resistor: fixed, composition, 15,000 ohms, ±10%, 1 W B*	24-15K	3			
R13	Resistor: fixed, wirewound, 1250 ohms, ±10%, 10 W S*	26-26	2			
R14	Resistor: fixed, composition, 1500 ohms, ±10%, 1 W B*	24-1500	1			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	STOCK NO.	#			
R15	Resistor: fixed, composition, 10,000 ohms, ±10%, 1 W B*	24-10K	2			
R16	Resistor: fixed, composition, 470 ohms, ±10%, 1 W B*	24-470	1			
R17, 18	These circuit references not assigned.					
R19	Resistor: fixed, composition, 1.5 megohms, ±10%, 1 W B*	24-1.5M	1			
R20	Resistor: fixed, composition, 47 ohms, ±10%, 2 W B*	25-47	1			
R21	Resistor: fixed, film type on glass rod body, 20 ohms, ±1%, 1 W Electrical value adjusted at factory AB*	331-20	1			
R22	Resistor: fixed, 100 ohms, ±5%, 4 W AB*	334-100	2			
R23	Resistor: fixed, composition, 33,000 ohms, ±10%, 1 W B*	24-33K	3			
R24, 25	Same as R6					
R26	Resistor: fixed, wirewound, 50 ohms, ±10%, 10 W S*	26-27	1			
R27	Resistor: fixed, composition, 330 ohms, ±10%, 1 W B*	24-330	2			
R28	Resistor: fixed, wirewound, 30,000 ohms, ±5%, 10 W S*	26-12	1			
R29	Same as R11					
R30	Resistor: variable, composition, linear taper 500 ohms, ±10%, I*	210-25	1			
R31	Resistor: fixed, composition, 1 megohm, ±10%, 1 W B*	24-1M	1			
R32	Resistor: fixed, composition, 330,000 ohms, ±10%, 1 W B*	24-330K	1			
R33	Resistor: variable, composition, 50,000 ohms, ±20%, 1/2 W I*	210-18	1			
R34	Same as R5					
R35	Resistor: variable, composition, linear taper 250,000 ohms, ±10% B*	210-44	1			
R36	This circuit reference not assigned					

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		hp STOCK NO.	#			
R37	Resistor: fixed, composition, 270,000 ohms, ±10%, 1 W	B*	24-270K	2			
R38	Resistor: fixed, wirewound, 25,000 ohms, ±10%, 10 W	S*	26-11	2			
R39	Resistor: fixed, composition, 120,000 ohms, ±10%, 1 W	B*	24-120K	1			
R40	Resistor: fixed, composition, 27,000 ohms, ±10%, 1 W	B*	24-27K	5			
R41	Resistor: fixed, composition, 33 ohms, ±10%, 1 W	B*	24-33	1			
R42	Resistor: fixed, composition, 12 ohms, ±10%, 1/2 W	B*	23-12	1			
R43	Resistor: fixed, wirewound, 1 ohm	HP*	212A-67C	1			
R44,45, 46	Resistor: fixed, composition, 330 ohms, ±10%, 2 W	B*	25-330	4			
R47,48	Resistor: fixed, composition, 100 ohms, ±10%, 2 W	B*	25-100	3			
R49	Same as R27						
R50	Resistor: fixed, composition, 560 ohms, ±10%, 1 W Electrical value adjusted at factory	B*	24-560	1			
R51	Resistor: fixed, composition, 39,000 ohms, ±10%, 1 W Electrical value adjusted at factory	B*	24-39K	1			
R52	Resistor: fixed, composition, 10,000 ohms, ±10%, 1/2 W	B*	23-10K	1			
R53 thru R60	Resistor: fixed, deposited carbon, 96.25 ohms, ±1%, 1/2 W	NN*	33-96.25	8			
R61 thru R64	Resistor: fixed, deposited carbon, 71.16 ohms, ±1%, 1/2 W	NN*	33-71.16	4			
R65,66, 67	Resistor: fixed, deposited carbon, 288.7 ohms, ±1%, 1 W	NN*	31-288.7	3			
R68,69	Resistor: fixed, deposited carbon, 142.3 ohms, ±1%, 1 W	NN*	31-142.3	2			
R70	Resistor: fixed, deposited carbon, 96.25 ohms, ±1%, 1 W	NN*	31-96.25	1			
R71	Resistor: fixed, wirewound, 600 ohms, ±10%, 20 W	S*	27-1	1			
R72,73	Resistor: fixed, composition, 220,000 ohms, ±10%, 2 W	B*	25-220K	2			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	STOCK NO.	#			
R74	Resistor: fixed, composition, 2200 ohms, ±10%, 1 W B*	24-2200	2			
R75	Resistor: fixed, composition, 470 ohms, ±10%, 2 W B*	25-470	1			
R76, 77	Resistor: fixed, composition, 4700 ohms, ±10%, 2 W B*	25-4700	2			
R78, 79	Resistor: fixed, composition, 3300 ohms, ±10%, 2 W B*	25-3300	2			
R80	Same as R44					
R81	Resistor: fixed, composition, 220 ohms, ±10%, 1/2 W B* Electrical value adjusted at factory	23-220	1			
R82	Same as R38					
R83	Same as R22					
R84	Same as R13					
R85	Resistor: fixed, composition, 1000 ohms, ±10%, 1 W B*	24-1000	2			
R86	Resistor: fixed, wirewound, 10,000 ohms, ±10%, 10 W S*	26-10	1			
R87	Resistor: fixed, wirewound, 330 ohms, ±10%, 5 W S*	26-75	2			
R88	Same as R47					
R89 thru R100	These circuit references not assigned					
R101	Same as R23					
R102	Resistor: fixed, composition, 15,000 ohms, ±5%, 1/2 W B*	23-15K-5	1			
R103	Resistor: fixed, composition, 2200 ohms, ±10%, 1 W B*	24-2200	3			
R104, 105	Resistor: fixed, composition, 27,000 ohms, ±10%, 2 W B*	25-27K	2			
R106	Resistor: fixed, composition, 3300 ohms, ±10%, 1 W B*	24-3300	1			
R107	Resistor: fixed, composition, 270,000 ohms, ±10%, 1/2 W B*	23-270K	1			
R108	This circuit reference not assigned					
R109	Same as R103					

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	STOCK NO.	#				
R110	Resistor: variable, composition, 2000 ohms, ±20%, 1/4 W I*	210-14	1				
R111	This circuit reference not assigned						
R112, 113	Resistor: fixed, composition, 390 ohms, ±10%, 1 W B*	24-390	1				
R114	Resistor: fixed, composition, 4700 ohms, ±10% 1 W B*	24-4700	1				
R115	Same as R9						
R116	Resistor: fixed, composition, 1500 ohms, ±10%, 1 W B*	24-1500	1				
R117	Resistor: fixed, composition, 47,000 ohms, ±10%, 1 W B*	24-47K	2				
R118	Resistor: fixed, composition, 270,000 ohms, ±10%, 1/2 W B*	23-270K	2				
R119	Resistor: fixed, composition, 5600 ohms, ±10%, 1 W B*	24-5600	1				
R120	Resistor: fixed, composition, 180,000 ohms, ±10%, 1 W B*	24-180K	1				
R121	Resistor: variable, composition, 200,000 ohms, ±20% I*	210-19	1				
R122, 123	Resistor: fixed, composition, 100,000 ohms, ±10%, 2 W B*	25-100K	2				
R124	Resistor: variable, composition, linear taper 500,000 ohms G*	210-20	1				
R125	Resistor: variable, composition, 3.5 megohms, ±20% B*	210-81	1				
R126	Resistor: fixed, composition, 2.2 megohms, ±10%, 1 W B*	24-2.2M	1				
R127	Same as R37						
R128	Resistor: fixed, composition, 18,000 ohms, ±10%, 1 W B*	24-18K	1				
R129	Same as R117						
R130	Same as R40						
R131	Same as R103						
R132AB	Resistor: variable, carbon, dual section, front section: 100,000 ohms rear section: 1000 ohms I*	210-74	1				

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	STOCK NO.	#			
R133	Resistor: fixed, composition, 680 ohms, ±10%, 1/2 W B*	23-680	1			
R134	Resistor: fixed, wirewound, 15,000 ohms, ±10%, 10 W S*	26-25	1			
R135	Same as R118					
R136	Resistor: fixed, wirewound, 3000 ohms, ±10% S*	26-3	1			
R137	This circuit reference not assigned					
R138	Resistor: fixed, composition, 2700 ohms, ±10%, 2 W B*	25-2700	1			
R139	Same as R15					
R140	Resistor: fixed, composition, 150,000 ohms, ±10%, 1 W B*	24-150K	1			
R141	Resistor: fixed, composition, 3300 ohms, ±10%, 1 W B*	24-3300	1			
R142	Resistor: variable, composition, 20,000 ohms, ±10%, 2.25 W B*	210-70	1			
R143	Resistor: variable, composition, linear taper 500 ohms, ±10%, I*	210-25	1			
R144	Resistor: fixed, deposited carbon, 3.28 megohms, ±1%, 1 W NN*	31-3.28M	1			
R145	Same as R23					
R146	Resistor: fixed, composition, 220 ohms, ±10%, 1 W B*	24-220	1			
R147	Resistor: fixed, composition, 56,000 ohms, ±10%, 1/2 W B*	23-56K	1			
R148	Same as R74					
R149	Same as R85					
R150	This circuit reference not assigned					
R151, 152, 153	Resistor: fixed, composition, 220,000 ohms, ±10%, 1 W B*	24-220K	4			
R154	Resistor: fixed, composition, 6800 ohms, ±10%, 1 W B*	24-6800	1			
R155	Resistor: fixed, composition, 75,000 ohms, ±5%, 1 W B* Electrical value adjusted at factory	24-75K-5	1			
R156	Resistor: fixed, composition, 27,000 ohms, ±10%, 1 W B*	24-27K	1			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		STOCK NO.	#			
R157	Same as R151 Electrical value adjusted at factory						
R158, 159, R160	Same as R40						
R161	Same as R87						
R162	Resistor: fixed, composition, 2700 ohms, ±10%, 1 W Electrical value adjusted at factory	B*	24-2700	1			
R163	Resistor: fixed, composition, 39,000 ohms, ±10%, 1/2 W	B*	23-39K	1			
R164	This circuit reference not assigned						
R165	Resistor: fixed, composition 15,000 ohms, ±10%, 1/2 W -hp- Electrical value adjusted at factory	B*	23-15K	1			
REL 1	Relay: DPDT, 24v dc	HP*	212A-60E	1			
S1	Switch, toggle: SPST	D*	310-11	1			
S2	This circuit reference not assigned						
S3	Switch, rotary: Polarity	W*	310-80	1			
S4-S100	These circuit references not assigned						
S101	Switch, toggle: DPDT	D*	310-54	1			
S102	Sync Selector Switch Assembly: complete	HP*	212A-19A	1			
	Sync Selector Switch: less components	HP*	310-81	1			
T1	Transformer, power	HP*	910-74	1			
T2	Transformer, filament	HP*	910-75	1			
T3-T100	These circuit references not assigned						
T101	Transformer, pulse: 4 leads	HP*	913-3	1			
T102, 103	Transformer, pulse: 6 leads	HP*	913-2	2			
V1	Tube, electron: 6X4	ZZ*	212-6X4	1			
V2	Tube, electron: 6L6GB	ZZ*	212-6L6GB	1			
V3	Tube, electron: 6W4GT	ZZ*	212-6W4GT	1			
V4	Tube, electron: OB2	ZZ*	212-0B2	2			
V5	This circuit reference not assigned						
V6	Tube, electron: HP45	ZZ*	212-HP45	2			
V7, 8, 9	Tube, electron: 6J6	ZZ*	212-6J6	3			
V10AB	Tube, electron: 12AX7	ZZ*	212-12AX7	1			
V11	Tube, electron: 6AS7G	ZZ*	212-6AS7G	2			
V12	Tube, electron: OD3	ZZ*	212-OD3	1			
V13	Tube, electron: 5U4GB	ZZ*	212-5U4GB	1			
V14	Same as V4						
V15	Tube, electron: 6AU6	ZZ*	212-6AU6	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗ STOCK NO.	#			
V16	Same as V6						
V17A, B	Same as V11						
V18 thru V100	These circuit references not assigned						
V101 thru V109	Tube, electron: 12AU7, 5963, or 7316	ZZ*	212-7316	9			
Z1	Pulse forming line	HP*	212A-60D	1			
	MISCELLANEOUS						
	Cable, pulse out, complete	HP*	212A-16B	1			
	Coupler, flexible	AK*	150-1	1			
	Connector, R.F. receptacle: type N PULSE OUT	LL*	125-UG58/U	1			
	Fan blade	BO*	314-44	1			
	Filter, power line	HP*	212A-95A	1			
	Fuseholder	T*	140-16	1			
	Indicator Light	II*	145-2	1			
	Insulator, standoff	AI*	34-1	2			
	Insulator plate, bakelite 2 x 2 x 3/32" for horizontally mounted HP45 tube	HP*	212A-41	1			
	Knob: ATTENUATOR DB, POLARITY, SYNC SELECTOR	HP*	G-74N	3			
	Knob: PULSE POSITION	HP*	G-74B	1			
	Knob: AMPLITUDE, PULSE RATE	HP*	G-74K	2			
	Knob: PULSE POSITION, (skirted)	HP*	G-74L	1			
	Knob: PULSE LENGTH	ZZ*	G-74Z	1			
	Motor Assembly	HP*	212A-97	1			
	Reactor Assembly: audio, 1.2h	HP*	212A-95C	1			
	Shield, for HP45 tube, asbestors, 3" long	HP*	212A-6A	1			
	Shock mounts for fan	Berry Cont. Inc.	149-18	1			
	Switch, attenuator: (less components)	W*	310-79	1			
	Window, dial	HP*	M-2	1			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
# Total quantity used in the instrument.

MANUAL CHANGES

MODEL 212A

PULSE GENERATOR

ERRATA:

R165: Change to resistor, fixed, composition, 15,000 ohms ±10%, ½ W; -hp- Stock No. 23-15K, Mfr., B

10-19-59